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ABSTRACT

The present document covers activities carried out by and under the auspices of the Joint Panel on Oceanographic Tables and Standards (JPOTS) over the period of 1983-1986. The first part is the report of the Chairman of JPOTS on the activities of the Panel during the period 1983-1985. Two major topics were considered by the Panel: (1) the production of Volume 4 of the International Oceanographic Tables, covering properties derived from the International Equation of State of Seawater (EOS-80); (2) the study of the thermodynamics of the carbon dioxide system in seawater. In addition, matters concerning nomenclature and the updating of information for oxygen saturation calculations were considered. The second part is a summary report of the first meeting of the JPOTS Editorial Panel on the Oceanographic Manual, which took place in Moscow, from 30 June to 4 July 1986. It gives the plans and contents of the proposed "Manual on Processing of Oceanographic Station Data." (Author)

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Progress on oceanographic tables and standards 1983-1986: Work and recommendations of the Unesco/SCOR/ICES/IAPSO Joint Panel

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36	The practical salinity scale 1978 and the international equation of state of seawater 1980. Tenth report of the Joint Panel on Oceanographic Tables and Standards, (JPOTS). Sidney, B.C., Canada, 1-5 September 1980. Sponsored by Unesco, ICES, SCOR, IAPSO. Available in Ar, Ch, F, R, S (*Примечание:* Этот доклад (текст идентичен) был первоначально издан только на английском языке под заголовком *Tenth report of the Joint Panel on Oceanographic Tables and Standards* (Десятый доклад Объединенной группы по океанографическим таблицам и стандартам)). Имеется на арабском, испанском, китайском, русском и французском языках.	1981	WG 10
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44	Algorithms for computation of fundamental properties of seawater. Endorsed by Unesco/SCOR/ICES/IAPSO Joint Panel on Oceanographic Tables and Standards and SCOR Working Group 51.	1983	—
45	The International System of Units (SI) in Oceanography Report of IAPSO Working Group on Symbols, Units and Nomenclature in Physical Oceanography. (SUN)	1985	—
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I N M E M O R I A M

Maurice Menaché

Maurice Menaché was born on 26 August 1907 in Aleppo, Syria. After receiving his secondary schooling in Syria, he began his university studies in Paris, but World War II interrupted his studies; he entered the French resistance movement. Forced to flee the advancing Nazis, his escape route led him to Spain where he was imprisoned. He managed to escape again, and joined the army of Maréchal Juin. After participating in the Italian campaign, he returned home as a war invalid.

He finished his formal scientific education at the Faculty of Sciences of the University of Paris, followed by oceanographic training in Denmark. In 1946, he began his career in France's "Office de la Recherche Scientifique et Technique d'Outre Mer" (ORSTOM, now "Institut Français de Recherche Scientifique pour le Développement en Coopération").

Mr. Menaché was fascinated by the problems of salinity of seawater and its relation to chlorinity and density. He was an admirer of the classical works of Knudsen, Forch and Sörensen, and treasured his copy of the French translation of their 1902 treatise in German.

Among other projects, he carried out research on the validity of the use of Copenhagen Standard Sea Water for the determination of chlorinity of Mediterranean water, and directed the major part

of the at-sea operational portion, in the Indian Ocean, of the French oceanographic contribution to the International Geophysical Year. He was the organizer and first director of the Centre Océanographique de Nosy Bé, Madagascar (1954-1961).

In addition to his didactic activities for ORSTOM, he taught physical oceanography at the Faculty of Sciences of the University of Paris. His scientific activities were in three basic domains: (1) metrology and methodology in analysis of seawater (chlorinity, oxygen, etc.); (2) estuarine studies; and (3) marine hydrology. He participated in numerous oceanographic campaigns, particularly in the Indian Ocean, and wrote or co-authored dozens of articles that were published in scientific journals.

Although he retired from ORSTOM in 1967 with the grade of "Inspecteur Général de Recherche", he continued his research activities at the laboratory of the Institut Océanographique, Paris, until finally illness overcame his tenacity.

It was particularly in the latter years of his life that Dr. Menaché became involved with international bodies working towards the establishment of internationally accepted standards. For example, although his first contacts with the International Bureau of Weights and Measures were in 1948, it was in 1968 that he began a decade of collaboration with the Bureau. During these years he worked on the absolute density of water and the verification of its relation to isotopic composition. His efforts contributed to the approval by the International Union of Geodesy and Geophysics (IUGG) in 1975 of the recommendation of the International Union of Pure and Applied Chemistry, calling for a new determination of the absolute density of water and its parameters.

He established a reputation in the international marine scientific community especially through his involvement in the work of the Joint Panel on Oceanographic Tables and Standards (JPOTS), which brought him into close collaboration with the Panel's sponsoring bodies: Unesco, the International Association for the Physical Sciences of the Ocean (IAPSO) and the International Council for the Exploration of the Sea (ICES). As an observer, he attended the 1965 and 1967 JPOTS meetings in Rome and Bern, and at the latter meeting was nominated to serve as the Unesco representative on the Panel. Also, he was designated as the Panel's representative on the IUGG Committee on Critical Data. During the fifteen years in which he was involved with the Joint Panel, he became known for his extreme precision in scientific definitions and terminology and for his diligence and devotion concerning the work of the Panel. In particular, his colleagues were impressed by his friendliness and generosity.

Mr. Menaché served as Chairman of the IAPSO Working Group on Symbols, Units and Nomenclature (SUN) from 1975 until he asked to be relieved of this duty, because of failing health, in 1983. The work of the "SUN Group" culminated in the production of "The International System of Units (SI) in Oceanography", which was issued in 1985 as a joint document: Unesco Technical Paper in Marine Science Number 45 and IAPSO Publication Scientifique Number 32.

In 1983, he became the first recipient of the IAPSO "Hard Work Award" as a token of the esteem of the Association. Those who have worked with Dr. Menaché share this esteem, which, it is felt, has been earned by his scientific achievements and by his enthusiasm not only for research and training but also for measures to facilitate the free communication among scientists and among people all over the world.

"Lauréat" of the Institut Océanographique, Maurice Menaché also held the French "Médaille Militaire", "Croix de Guerre" and the rank of "Officier dans l'Ordre National du Mérite". He died on 9 September 1986, a few months before his eightieth birthday. The international marine scientific community will remember him as an eminent member of their ranks. For years, many will regret the passing of a friend.

PREFACE

This series, the Unesco Technical Papers in Marine Science, is produced by the Unesco Division of Marine Sciences as a means of informing the scientific community of recent advances in oceanographic research and on recommended research programmes and methods.

The texts in this series are prepared in co-operation with non-governmental scientific organizations. Many of the texts result from research activities of the Scientific Committee on Oceanic Research (SCOR) and are submitted to Unesco for printing following final approval by SCOR of the relevant working group report.

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ABSTRACT

The present document covers activities carried out by and under the auspices of the Joint Panel on Oceanographic Tables and Standards (JPOTS) over the period of 1983-1986. The first part is the report of the Chairman of JPOTS on the activities of the Panel during the period 1983-1985. Two major topics were considered by the Panel: (1) The production of Volume 4 of the International Oceanographic Tables, covering properties derived from the International Equation of State of Seawater (EOS-80); (2) the study of the thermodynamics of the carbon dioxide system in seawater. In addition, matters concerning nomenclature and the updating of information for oxygen saturation calculations were considered. The second part is a summary report of the first meeting of the JPOTS Editorial Panel on the Oceanographic Manual, which took place in Moscow, from 30 June to 4 July 1986. It gives the plans and contents of the proposed "Manual on Processing of Oceanographic Station Data".

RESUME

Le présent document décrit les activités menées à bien par le Groupe mixte d'experts sur les tables et les normes océanographiques (JPOTS) ou sous son égide pendant la période 1983-1986. La première partie contient le rapport du Président du JPOTS sur les activités du Groupe au cours de la période 1983-1985. Celui-ci a étudié deux grandes questions : (1) L'établissement du Volume 4 des Tables océanographiques internationales traitant des propriétés tirées de l'Equation internationale d'état de l'eau de mer (EOS-80) ; et (2) L'étude de la thermodynamique du régime du dioxyde de carbone dans l'eau de mer. Ont été examinés en outre des problèmes relatifs à la nomenclature et à la mise à jour de l'information concernant le calcul de la saturation en oxygène. La deuxième partie contient le rapport succinct de la première réunion du Comité de rédaction du Manuel océanographique du JPOTS, tenue à Moscou du 30 juin au 4 juillet 1986. Ce rapport présente le plan et le contenu du "Manuel de traitement des données des stations océanographiques" qu'il est proposé d'établir.

RESUMEN

En el presente documento se reseñan las actividades efectuadas por la Comisión Conjunta de Normas y Tablas Oceanográficas (JPOTS), o bajo sus auspicios, en el periodo 1983-1986. La primera parte contiene el informe del Presidente de la JPOTS sobre las actividades de la Comisión en 1983-1985. La Comisión examinó dos temas principales: 1) la producción del Volumen 4 de las Tablas Oceanográficas Internacionales, que abarca las propiedades derivadas de la Ecuación Internacional de Estado del Agua del Mar (ECS-80); 2) el estudio de la termodinámica del sistema del dióxido de carbono en el agua de mar. Además, se examinaron cuestiones relativas a la nomenclatura y la actualización de las informaciones relativas a los cálculos de saturación en oxígeno. La segunda parte contiene el informe resumido de la primera reunión del Comité Editorial de la JPOTS sobre el Manual Oceanográfico, celebrada en Moscú del 30 de junio al 4 de julio de 1986. En ese informe figuran los planes y contenidos del propuesto "Manual sobre Procesamiento de Datos procedentes de Estaciones Oceanográficas".

РЕЗЮМЕ

В настоящем документе рассматриваются мероприятия, проведенные Объединенной группой по океанографическим таблицам и стандартам (ОГОТС) и под ее эгидой за период 1983-1986 гг. В первой части содержится доклад председателя ОГОТС о деятельности Группы за период 1983-1985 гг. Группой были рассмотрены две основные темы: (1) издание тома 4 Международных океанографических таблиц, включающих свойства, полученные с помощью Международного уравнения состояния морской воды (EOS-80); (2) исследование термодинамики системы обмена углекислого газа в морской воде. Кроме того, были рассмотрены вопросы, касающиеся номенклатуры и обновления информации, касающейся расчета насыщенности кислородом. Вторая часть представляет собой краткий доклад о первом совещании редакторской группы ОГОТС по Океанографическому справочнику, которое проходило в Москве с 30 июня по 4 июля 1986 г. В нем приводятся планы и содержание предложенного "Руководства по обработке данных океанографической станции".

ملخص

تشمل هذه الوثيقة الأنشطة التى نهض بها الفريق المشترك للجداول والمعايير الأوقيانوغرافية أو التى نفذت تحت اشرافه فى الفترة ١٩٨٣ - ١٩٨٦. ويتكون الجزء الأول من تقرير رئيس الفريق المشترك للجداول والمعايير الأوقيانوغرافية بشأن أنشطة هذا الفريق خلال الفترة ١٩٨٣ - ١٩٨٥. وقد درس الفريق موضوعين رئيسيين هما : (١) نشر المجلد الرابع للجداول الأوقيانوغرافية الدولية التى تشمل خصائص مستمدة من المعادلة الدولية لحالة مياه البحر (EOS-80)، (٢) دراسة الديناميكية الحرارية لنظام ثانى أوكسيد الكربون فى مياه البحر . وبالاضافة الى ذلك تم دراسة مسائل تتعلق بوضع المصطلحات وباستيفاء المعلومات اللازمة لحسابات التشبع بالأوكسيجين . أما الجزء الثانى فهو عبارة عن تقرير موجز للاجتماع الأول الذى عقده فى موسكو من ٣٠ يونيو/حزيران الى ٤ يوليو/تموز ١٩٨٦ فريق التحرير المعنى بالدليل الأوقيانوغرافى والتابع للفريق المشترك للجداول والمعايير الأوقيانوغرافية. وترد فيه خطط ومضامين الوثيقة المقترح اصدارها بعنوان "دليل عن معالجة بيانات المحطة الأوقيانوغرافية".

摘　要

本文件述及1983－1986年期间海洋学图表与标准联合委员会(JPOTS)实施及该委员会赞助的各项活动。第一部分是海洋学图表与标准联合会主席关于该委员会1983－1985年期间各项活动的报告。委员会审议了两大专题：(1)编制国际海洋学图表第4卷，其中包括通过国际海水状态方程式(EOS-80)推算出来的各种特性；(2)对海水中二氧化碳系统的热力学进行研究。此外，还审议了有关术语及补充更新有关氧饱和状态计算的资料等问题。第二部分是海洋学图表与标准联合委员会海洋学手册编辑小组第一次会议的简要报告，这次会议于1986年6月30日至7月4日在莫斯科举行。报告对建议的“海洋站资料处理手册”提出了规划和目录。

TABLE OF CONTENTS

Page

Abstract 1

PART I: JOINT PANEL ON OCEANOGRAPHIC TABLES AND STANDARDS
Report on Activities during 1983-1985

1. Introduction 3

2. Addresses of Attending Members and Guests 3

3. Meeting of July 5-8, 1983, La Jolla 5
   3.1 General Items 5
   3.2 Volume 4 of Oceanographic Tables 5

4. Meeting of Carbon Dioxide Sub-Panel,
   August 26-27, 1983, Kiel 6

5. Meeting of Sub-Panel on Volume 4,
   December 10, 1984, La Jolla 7

6. Meeting of Carbon Dioxide Sub-Panel,
   December 11-12, 1984, La Jolla 8

7. Matters Arising from Correspondence 8
   7.1 Practical Salinity 9
   7.2 Density Anomaly 9
   7.3 The Use of Conductivity Ratio (not Conductivity)
   in Calibration Curves for Oceanographic Instruments 10
   7.4 Secondary Standard Seawater 11
   7.5 Oxygen Solubility 11
   7.6 SUN Report 11

8. References 12

Appendix 1. Solubility of Oxygen in Seawater 13

Appendix 2. Letter to Manufacturers of CTD Equipment 19

PART II: JOINT EDITORIAL PANEL ON THE OCEANOGRAPHIC MANUAL
Report of First Meeting, Moscow State University,
Moscow, 30 June to 4 July 1986.

1. Opening 23
   1.1 Election of Chairman and Rapporteur 23
   1.2 Agenda 23
   1.3 List of Documents 23

2. Guidelines for the Editorial Panel and Objectives
   of Manual 24
   2.1 Guidelines 24
   2.2 Objectives 24

Page

3. Review of Existing Manuals and Guides 25

4. Details of the Manual 25
4.1 Scientific Background 25
4.2 Processing Procedures 26
4.3 Discussion on Overall Layout of Manual 29

5. Computational Needs for the Presentation of the Manual 29

6. Future Meeting 30

Recommendation 30

Visit to the Normal Seawater Service, Analytical Laboratory of P.P. Shirshov Institute of Oceanology, U.S.S.R. Academy of Science, Moscow 31

Closure of the Meeting 31

References 32

ANNEX I - Address by Dr. S. Morcos (Unesco) 33

ANNEX II - List of Participants 37

ANNEX III - Annotated Provisional Agenda 39

ANNEX IV - List of Documents 41

ANNEX V - Preliminary Considerations on the Structure of the Future Manual for Processing of Oceanographic Data by O. I. Mamayev 43

ANNEX VI - AJAX Expedition, RV "Knorr", Station 66, 17 January 1984 49

ANNEX VII - Proposed Table of Contents of the Manual on Processing of Oceanographic Station Data 59

PART I

JOINT PANEL ON OCEANOGRAPHIC TABLES AND STANDARDS

Report on Activities

during 1983-1985

1. Introduction

During the period of 1983-1985 several *ad hoc* meetings have been convened both for consideration of matters arising from the establishment of the Practical Salinity Scale and the Equation of State of Seawater (UNESCO, 1981a,b,c,d; UNESCO, 1983a), and for consideration of thermodynamic relationships in the carbon dioxide system in seawater (UNESCO, 1983b). In this report brief summaries of these meetings are presented. The results of the deliberations of the carbon dioxide sub-panel of JPOTS will be presented as a separate report.

The present report covers three meetings held during the period of 1983-1985:

(1) A meeting in July 1983 of selected panel members and invited experts to consider the requirements for the production of Volume 4 of the Oceanographic Tables; i.e., a table of properties derived from the equation of state of seawater;

(2) A meeting in August 1983 of the subpanel on the thermodynamics of the carbon dioxide system in seawater;

(3) A meeting in December 1984 of the sub-panel on Volume 4 of the Oceanographic Tables, and of the sub-panel on the thermodynamics of the carbon dioxide system in seawater.

In addition several matters, particularly concerning the problem of nomenclature for salinity and density anomaly, were handled by correspondence.

2. Addresses of attending members and guests

Dr. R. Bates	Department of Chemistry University of Florida Gainesville, FL 32611 USA
Dr. A. Dickson	Scripps Institution of Oceanography University of California, San Diego La Jolla, CA 92093 USA
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3. **Meeting of July 5-8, 1983 - La Jolla**

The following persons were in attendance: Dr. N.P. Fofonoff; Dr. J.M. Gieskes (Chairman), Dr. E. LaFond, Dr. E.L. Lewis; Dr. O. Mamayev; Dr. S. Morcos; Dr. R. Perkin; Dr. A. Poisson; Prof. J.L. Reid.

The meeting commenced at the Scripps Institution of Oceanography on Tuesday, July 5, 1983 at 2 p.m. It was decided to discuss first some general items, before coming to the major item of business, i.e., a discussion of the contents and layout of the Oceanographic Tables, Volume 4: Derived properties from the equation of state of seawater.

3.1. **General items**

3.1.1. Dr. Lyn Lewis indicated that some errors occurred in the Russian language version of the UNESCO Technical Report 39 (Oceanographic Tables Volume 3). Dr. Oleg Mamayev agreed to provide a corrected version to Dr. Selim Morcos of UNESCO.

3.1.2. The meeting considered a proposal by the director of the Institut fuer Meereskunde of the Academy of Sciences of the German Democratic Republic to organize a working group on "Intercomparison of high precision in-situ sensors". JPOTS agrees that SCOR should be encouraged to form such a working group, perhaps in close cooperation with Working Group 51 (WG-51).

3.1.3. A major item for discussion was the proposed document on Algorithms for Oceanographic Computations by N.P. Fofonoff and R. Millard. This document was an amended version of a previous one circulated to the JPOTS membership. A number of suggestions were made, especially concerning the omission of absolute conductivity values and with respect to the drawing of validity boundaries in specific examples.

Dr. Fofonoff agreed that conductivity ratios should be used in the algorithms, but urged that JPOTS should consider the problem of absolute conductivity in the future.

During 1983 the requested amendments have been made and circulated.

Meantime UNESCO has published No. 44 of the UNESCO Technical Papers in Marine Science: "Algorithms of Fundamental Properties of Seawater" (UNESCO, 1983a).

3.2. Volume 4 of Oceanographic Tables

The most important item for discussion during the July meeting was on the layout of the Oceanographic Tables, based on the Practical Salinity Scale 1978 (PSS78) and the Equation of State of Seawater 1980 (EOS80).

Dr. Oleg Mamayev presented a draft of the Tables, prepared by him at the request of UNESCO. This document as well as socalled LaFond Tables (LaFond, 1951) were the basis for the ensuing discussions.

As a result of the thorough discussions by the Panel, Dr. Oleg Mamayev was requested to revise his suggested Table of Contents.

Dr. E. LaFond suggested that each table be preceded by a sample calculation much in the way as was done in his own oceanographic tables (LaFond, 1951). The membership strongly endorsed this concept.

In July 1984 Dr. R. Millard of Woods Hole finished a draft of Volume 4 under an UNESCO contract. This table was further discussed in December 1984 (see below).

An important topic of discussion was the possible production of an "Oceanographic Manual" in the model of the U.S. Navy's publication on "Processing of Oceanographic Data" (LaFond, 1951). It was agreed that the production of such a manual was not under the mandate of JPOTS, although JPOTS strongly endorses that such a manual be produced through UNESCO/SCOR. Certainly selected members of JPOTS could serve on a working group established to prepare such a document.

After further discussion with SCOR, IAPSO, ICES and UNESCO a JPOTS Editorial Board for the production of this manual has been nominated, with the following membership: Dr. H. Dooley (ICES), Dr. O. Mamayev (UNESCO), Dr. R. Millard (SCOR) and Dr. K. Taira (IAPSO). Dr. O. Mamayev has begun consultation on this matter through correspondence. A possible meeting of the Editorial Panel is envisioned for 1986.

4. Meeting of carbon dioxide subpanel, August 26 and 27, Kiel

The following persons attended the meeting: Dr. R. Bates; Dr. D. Dyrssen; Dr. J.M. Gieskes (Chairman); Dr. F.J. Millero; Dr. S. Morcos; Dr.A. Poisson; Dr. R.M. Pytkowicz.

The meeting started on August 26 at 9:30 a.m. Professor Wolfgang Krauss welcomed the membership, as did Professor Jan Duinker. JPOTS appreciates the hospitality of Professors Krauss and Duinker, who made it possible to hold this meeting at the Institut fuer

Meereskunde in Kiel.

The discussions of the CO_2 subpanel focused on the preliminary report of the subpanel, which has appeared in the series on UNESCO Technical Papers in Marine Science (UNESCO, 1983b). The contents of the report were discussed in detail and, based on new information, various improvements were suggested. Special attention was given to:

(1) Newly obtained data on the dissociation constants of boric acid in seawater (A. Dickson and R. Bates);

(2) New buffers useful in seawater (R. Bates).

A major point of discussion was the intercomparison of the two recent data sets on the dissociation constants of carbonic acid in seawater. Though there exists a systematic discrepancy between the two data sets (UNESCO, 1984) it was decided to attempt an investigation into pooling the data sets.

It was agreed by the subpanel that during 1984 various panel members would work together in drafting a final version of a report to the sponsoring agencies.

The final report should contain:

(1) An introduction to the thermodynamics of the CO_2 system;

(2) A section on the performance of calculations using the thermodynamic information;

(3) A section on the intercomparison of pH scales, pK_1^I, pK_2^I, pK_B^I and the possible pooling of the available information;

(4) A section on the information available on the solubilities of various carbonate phases.

5. **Meeting of sub-panel on Volume 4, December 10, 1984, La Jolla**

The following persons atended this meeting: Dr. J.M. Gieskes (Chairman); Dr. E. LaFond; Dr. R. Millard; Dr. F.T. Millero; Dr. S. Morcos; Dr. A. Poisson; Dr. R. Perkin; Dr. J. Reid.

The Chairman introduced to the membership the background leading to the necessity of producing a set of tables based on the new equation of state for seawater. Dr. Robert Millard was acknowledged for the large amount of effort in producing the existing draft of Volume 4.

Because of the planned Oceanographic Manual it was decided that there would be no need to precede every table of Volume 4 with a detailed sample calculation. Examples of interpolations will be given in the introduction to Volume 4.

It was decided that tables on the adiabatic lapse rate should be redone using EOS-80 so as to cover the lower salinity range. Dr. F.J. Millero commented that expansibilities may change slightly if a more accurate pure water equation is adopted. The present version due to Biggs covers only the temperature range of 0-40°C.

Nomenclature in the Tables was considered and it was decided to cleave to the recent SUN report adopted by IAPSO (UNESCO, 1985), which means using γ for the density anomaly, and δ for the specific volume anomalies. Unless specifically defined, no subscripts such as δ_t will appear, but bracketed variables will be used in accordance to SUN usage.

At the end of the meeting there was a long discussion considering the special definition of the specific volume anomaly used in the Soviet literature, i.e., subtraction of 0.9 x $10^{-3}m^3kg^{-1}$. A number of panel members questioned the need for including a second definition of specific volume anomaly, especially in view of the adoption of the SUN recommendations. It was decided to include tables using the above definition, but to delegate them to an appendix, and to include a paragraph in the introduction to Volume 4, discouraging their use.

The final version of Volume 4 has been circulated to the JPOTS membership for comment in September 1985, and publication is expected in early 1987.

6. **Meeting of carbon dioxide subpanel, December 11 and 12, 1984 - La Jolla**

The following persons were in attendance: Dr. R. Bates; Dr. A. Dickson ; Dr. J.M. Gieskes (Chairman); Dr. F.J. Millero; Dr. S. Morcos; Dr. A. Poisson; Dr. M. Wedborg. Dr. J. Weare (University of California, San Diego) was present as an observer; Dr. R.M. Pytkowicz was unable to attend.

Special attention was paid to the possible pooling of thermodynamic information on the carbonic acid dissociation constants, as well as to information on boric acid dissociation constants. Special attention was given to various pH scales and agreement was reached to recommend the use of scales based either on the concentration of free hydrogen ion or the concentration of hydrogen ion free *and* combined with constituents (sulfate, borate, fluoride, etc.)of the seawater. Knowledge of carbonate solubilities was still considered to be ambiguous. However, the subpanel agreed that a consistent picture on the thermodynamics of the carbon dioxide system in seawater is now possible. A detailed report is in preparation for publication in the UNESCO Technical Papers in Marine Science Series. This will replace the previous report (UNESCO, 1983b). Publication in early 1987 is expected.

7. **Matters arising from correspondence**

Various matters of concern to JPOTS have arisen during the period 1983-1985. Most of these have been handled by correspondence, but below JPOTS recommendations are summarized.

7.1. **Practical Salinity**

During the meeting of JPOTS in Sidney, B.C. (UNESCO, 1981a) it was decided that salinities based on the Practical Salinity Scale 1978 were to be expressed by dimensionless numbers one thousand times larger than those used in previous definitions. Indeed, in principle, previously established salinity scales were defined on a mass fraction basis (mass of "salt" per mass of solution), and under the SI concept would be dimensionless. The expressions parts per thousand or $^{o}/_{oo}$ or 10^{-3} were only used to indicate that the weight fraction was multiplied by a factor of 1000. During the work to establish the practical salinity scale, the primary standard salinity (S = 35.000) was chosen to equal that of standard seawater, so as to provide continuity with previous salinity scales (UNESCO, 1981a,b). The standard KCl solution was chosen to yield a conductivity ratio (at 15°C and standard atmospheric pressure) of K_{15} = 1.00000 when compared with S = 35.000 standard seawater. All the work to establish PSS 78 and EOS 80 was then carried out on S = 35 standard seawater weight diluted by distilled water or carefully evaporated (UNESCO, 1981a,b).

Notwithstanding the fact that the definition of Practical Salinity (UNESCO, 1981a,b) omits units or a designator, some members of the panel and of the oceanographic community felt that the issue of a possible designator (or units) should be considered further. For these reasons the JPOTS Chairman polled the panel as well as interested experts on this matter in order to establish a consensus. The main result of this survey is that cogent reasons exist that *no* designator or units should be assigned to practical salinity. Henceforth practical salinity should be expressed by a *dimensionless number only* and should be written as, e.g., S = 34.960. Of importance, however, is that oceanographic publications should clearly state that PSS78 is being used, a usage mandatory as from January 1, 1982. After that usage of S = 34.960 or "the salinity is 34.960" should suffice. The IAPSO sponsored SUN report on units and nomenclature in oceanography is consistent with this concept. This SUN report has been published by UNESCO during 1985 (UNESCO, 1985).

7.2. **Density anomaly**

Traditionally the symbol σ (S,t,p) or σ_T has been used by oceanographers in relation to the specific density anomaly or the "Knudsen parameter":

$$\sigma = (\text{relative density} - 1) \times 1000.$$

With the arrival of EOS 80 and the production of Volume 4 and the Algorithms for Oceanographic Computations the use of absolute density has been advocated (ρ, kg m^{-3}). From this one then derives the density anomaly, which equals ρ - 1000 kg m^{-3}. This quantity, of course, is different from the Knudsen parameter. M. Maurice Menache of the SUN Working Group of IAPSO, proposed the usage of a different symbol for these purposes:

$$\gamma(S,t,p) = \rho(S,t,p) - 1000 \text{ kg m}^{-3}$$

A survey of the oceanographic community on this issue revealed no consensus on this issue, some favoring σ (S,t,p), others $\Delta\rho$, and others γ (S,t,p).

For these reasons the Chairman of JPOTS has given his support to the SUN Working Group proposal to use γ as the officially designated symbol. Again, if another symbol is used (e.g., σ (S,t,p) or $\Delta\rho$ (S,t,p) it should be well indicated in the text that this is not the Knudsen parameter in terms of relative density. Volume 4 of the Oceanographic Tables will adhere to the SUN recommended symbol.

7.3. **The use of conductivity ratio (not conductivity) in calibration curves for oceanographic instruments**

At regular times various members of JPOTS have been queried about the use of the Practical Salinity Scale (PSS 78) in algorithms for *in situ* instrument calibration. Often manufacturers express their measurements in terms of conductivities, whereas in reality the measurements yield a conductivity with reference to a standard. For these reasons Dr. E.L. Lewis has prepared a statement on this issue, which JPOTS intends to disseminate to manufacturers and appropriate trade journals.

The Practical Salinity Scale of 1978 (PSS 78) defines salinity in terms of a conductivity ratio between the sample water and that of standard seawater at 15°C. The standard seawater is in turn defined as having a conductivity ratio of unity at 15°C with respect to a potassium chloride solution of specified concentration by weight. Since January, 1982 the oceanographic community as represented by their international organizations, ICES, IAPSO and SCOR, has made the use of the Practical Salinity Scale 1978 mandatory in their publications and have strongly suggested that its use should be one of the criteria for acceptance by technical or scientific journals.

The absence of mention of conductivity is quite deliberate. Our ability to measure the conductivity of any electrolyte is less exact than that required for the accurate determination of salinity and this is reflected in the widely varying estimates of the conductivity of standard seawater quoted in the literature. This uncertainty is the reason for the existence of standard seawater, a calibration standard which allows the oceanographer to determine conductivity ratios by direct comparison. Since the measurements are, therefore, always ratios, there is no need to introduce absolute conductivities. Thus it is unfortunate that instrument manuals produced by a number of manufacturers persist in utilizing conductivity in data reduction equations as this creates possibilities of systematic error in comparison between various instruments. Implicit within the coefficients of the manufacturer's equation is a specific value for the conductivity of the standard water which may or may not be the same as that of another manufacturer. Utilization of any given equation means that the particular value selected by that manufacturer is incorporated within the final data produced.

It is strongly recommended that all new editions of operating instructions be altered so as to reflect a ratio value rather than a conductivity value. This may be achieved with trivial work by dividing through the coefficients of each factor in the equation by the value of the conductivity for standard seawater originally utilized in producing the equation.

Operators using equipment calibrated in the old fashioned way should write to the manufacturer asking for the value of conductivity used by him and carry out the division process themselves. This enables direct entry into the algorithms for the PSS 78.

A special note on this subject has been prepared for dispersal to manufacturers of CTD equipment (Appendix 2).

7.4 **Secondary standard seawater**

One of the standing practices in oceanography is the production of standard seawater in countries where large quantities is required, principally designed to avoid purchasing the IAPSO Standard Seawater prepared by the Institute of Oceanographic Sciences (IOS), Wormley, United Kingdom. JPOTS is particularly concerned about the calibration of these standards, and recommends that these standards be considered as *secondary standards* upon the condition that they are calibrated against *IAPSO Standard Seawater* which in turn is standardized against the primary KCl standard (UNESCO, 1981a,b).

7.5. **Oxygen solubility**

Since the publication of the UNESCO International Tables on oxygen solubility in seawater, an error was noticed in the algorithm used for the generation of this table (UNESCO, 1981a). Since that time more precise measurements of oxygen solubility have been carried out so that the recommendation of a new formula for oxygen solubility is called for. JPOTS endorses the formula proposed by member F.J. Millero as given in Appendix 1 of this report. JPOTS suggests that users of the oxygen solubility tables are made aware of this problem, and that a future reprinting of the oxygen tables should use the newly recommended formula in the generation of these tables. The opinion of JPOTS will be solicited during 1986.

7.6. **SUN Report**

The SUN report (UNESCO, 1985) has been distributed to the Joint Panel and commentaries, if any, have been requested. No negative comments have been received and JPOTS recommendations for nomenclature are consistent with the SUN report. The chairman of JPOTS, therefore, has forwarded the official approval of the SUN report to the President of SCOR.

8. References

LaFond, E.C. (1951). Processing Oceanographic Data. H.O. PUB. No. 614 - U.S. Navy Hydrographic Office, Washington, D.C., pp. 114.

UNESCO (1981a). The practical salinity scale 1978 and the international equation of state of seawater 1980. Tenth Report of the Joint Panel on Oceanographic Tables and Standards, Sidney, B.C., September 1980. Unesco Technical Papers in Marine Science, No. 36, pp. 25.

UNESCO (1981b). Background Papers and Supporting Data on the Practical Salinity Scale 1978. Unesco Technical Papers in Marine Science, No. 37, pp. 144.

UNESCO (1981c). Background Papers and Supporting Data on the International Equation of State of Seawater 1980. Unesco Technical Papers in Marine Science, No. 38, pp. 192.

UNESCO (1981d). International Oceanographic Tables, Vol. 3. Unesco Technical Papers in Marine Science, No. 39, pp. 111.

UNESCO (1983a). Algorithms for Computation of Fundamental Properties of Seawater. Unesco Technical Papers in Marine Science, No. 44, pp. 53.

UNESCO (1983b). Carbon Dioxide Sub-group of the Joint Panel on Oceanographic Tables and Standards. Unesco Technical Papers in Marine Science, No. 42, pp. 30.

UNESCO (1985). The International System of Units (SI) in Oceanography. Unesco Technical Papers in Marine Science, No. 45, pp. 124.

APPENDIX 1

SOLUBILITY OF OXYGEN IN SEAWATER

by

FRANK J. MILLERO

Recently Benson and coworkers (1979, 1980, 1984) have made very precise measurements on the solubility of oxygen in water and seawater. These measurements were made from 0 to 45°C and S = 0 to 50. The results have an estimated uncertainty of 0.1% which is better than the equations (0.2%) developed by Weiss (1970) based on the earlier measurements of Carpenter (1966) and Murray and Riley (1969). There is some confusion over the interpretation of the equations of Weiss (1970). This is made clear in the following paragraph quoted from Benson and Krause (1980).

> "In 1976, Postma et al. constructed the UNESCO International Oceanographic Tables from the equations of Weiss. Unfortunately, they apparently assumed that the values of Weiss were given as the volume the gas would occupy at STP if it were ideal. (The factor 89.23 used by Postma et al. to convert from volume of gas at STP to μg-atoms is equivalent to 22,414 $cm^3 . mol^{-1}$.) In fact, Weiss (pers. comm.) intended his values to be expressed in terms of the volume which would be occupied by a real gas at STP. (The corresponding conversion factor would be 89.318, which is equivalent to 22,392 $cm^3 . mol^{-1}$.) The UNESCO values are systematically low by from 0.15 to 0.35%."

A comparison of the differences between the UNESCO Tables (1976) and the new measurements are given in Table 1. At low temperatures the differences are as high as 1.3 μmol kg^{-1} (0.4%) while the differences at temperature between 15 to 35°C are $\sim$0.6 μmol kg^{-1} (0.3%) for S = 35 seawater.

A comparison of the new measurements and the equations of Weiss (1970) is given in Table 2. As is quite apparent from these comparisons the agreement is within 0.2% over most of the oceanographic range of t and S (which is the quoted precision of the Weiss equation). The differences at low temperatures and high salinity are significant, however, and I feel that the new work of Benson and Krause should be adopted by the joint panel.

The solubilities for seawater solutions (Benson and Krause, 1984) can be determined from the equations (t = 0 to 40°C. S = 0 to 40)

$$\ln C\ (\mu mol\ kg^{-1}) = -135.29996 + 1.572288 \times 10^5/T - 6.637149 \times 10^7/T^2 + 1.243678 \times 10^{10}/T^3 - 8.621061 \times 10^{11}/T^4 - S\ (0.020573 - 12.142/T + 2{,}363.1/T^2).$$

Here T = 5°C + 273.15.

Tables for the solubility of O_2 in seawater can be generated from this equation. I should point out that the pure water results of Benson and Krause (1984) have already been accepted for freshwater work (Mortimer, 1981), and their freshwater and seawater results (Benson and Krause, 1984) have been approved for publication in the 16th Edition of Standard Methods for the Examination of Water and Waste Water (1985).

TABLE 1

Percent Differences Between the concentrations of O_2 in Seawater Obtained from the UNESCO (1976) Tables and Benson and Krause (1984).

	Δ (%)[a]					
Temp.	S=0	S=10	S=20	S=30	S=35	S=40
0	-0.2	0.0	0.1	0.3	0.4	0.5
5	-0.2	-0.1	0.0	0.1	0.2	0.2
10	-0.2	-0.1	-0.1	0.0	0.0	0.0
15	-0.2	-0.2	-0.1	-0.2	-0.2	0.1
20	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3
25	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3
30	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3
35	-0.3	-0.3	-0.2	-0.2	-0.2	-0.2
40	-0.1	-0.1	0.0	0.0	0.1	0.1

a) $$\Delta = \frac{O_2(\text{UNESCO}) - O_2\ (\text{Benson and Krause})}{O_2\ (\text{Benson and Krause})} \times 100\%$$

TABLE 2

Percent Differences Between the Concentrations of O_2 in Seawater Obtained from the Equations of Weiss (1970) and Benson and Krause (1984)

	Δ (%)[a]					
Temp.	S=0	S=10	S=20	S=30	S=35	S=40
0	-0.1	0.0	0.2	0.4	0.5	0.6
5	-0.1	0.0	0.1	0.2	0.2	0.3
10	-0.1	0.0	0.0	0.1	0.1	0.1
15	-0.1	-0.1	-0.1	-0.1	-0.1	0.0
20	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2
25	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2
30	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2
35	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1
40	0.0	0.0	0.1	0.1	0.2	0.2

[a] $\Delta = \dfrac{O_2(\text{Weiss}) - O_2(\text{Benson and Krause})}{O_2(\text{Benson and Krause})} \times 100\%$

References

Benson, B.B. and D. Krause, Jr. 1980. The concentration and isotopic fractionation of gases dissolved in fresh water in equilibrium with the atmosphere, 1. Oxygen. Limnol. Oceanogr., *25*:662-671.

Benson, B.B., D. Krause, Jr. and M.A. Peterson. 1979 The solubility and isotopic fractionation of gases in dilute aqueous solution, 1. Oxygen. J. Solution Chem., *8*:655-690.

Benson, B.B. and D. Krause, Jr. 1984. The concentration and isotopic fractionation of oxygen dissolved in freshwater and seawater in equilibrium with the atmosphere. Limnol. Oceanogr., *29*:620-632.

Carpenter, J.H. 1966. New measurements of oxygen solubility in pure and natural water. Limnol. Oceanogr., *11*:264-277.

Mortimer, C.H. 1981. The oxygen content of air saturated freshwaters over the ranges of temperature and atmospheric pressure of limnological interest. Mitt. Int. Ver. Theor. Angew. Limnol., *22*.

Murray, C.N. and J.P. Riley. 1969. The solubility of gases in distilled water and seawater. 2. Oxygen. Deep-Sea Res., *16*:311-320.

Weiss, R.F. 1970. The solubility of nitrogen, oxygen and argon in water and seawater. Deep-Sea Res., *17*:721-735.

APPENDIX 2

October 29, 1985

To: Manufacturers of CTD Equipment

From Joris M. Gieskes
Chairman of the Joint Panel on Oceanographic Tables and Standards

Subject: Practical Salinity Scale

The Joint Panel on Oceanographic Tables and Standards wishes to bring to your attention the following matter concerning the conversion of CTD data to Practical Salinity values.

The Practical Salinity Scale of 1978 (PSS 78) defines salinity in terms of a conductivity ratio between the sample water and that of standard seawater at 15°C. The standard seawater is in turn defined as having a conductivity ratio of unity at 15°C with respect to a potassium chloride solution of specified concentration by weight. Since January, 1982, the oceanographic community as represented by their international organizations, ICES, IAPSO and SCOR, has made the use of the Practical Salinity scale 1978 mandatory in their publications and have strongly suggested that its use should be one of the criteria for acceptance by technical or scientific journals.

The absence of mention of conductivity is quite deliberate. Our ability to measure the conductivity of any electrolyte is less exact than that required for the accurate determination of salinity and this is reflected in the widely varying estimates of the conductivity of standard seawater quoted in the literature. This uncertainty is the reason for the existence of standard seawater, a calibration standard which allows the oceanographer to determine conductivity ratios by direct comparison. Since the measurements are, therefore, always ratios, there is no need to introduce absolute conductivities. Thus it is unfortunate that instrument manuals produced by a number of manufacturers persist in utilizing conductivity in data reduction equations as this creates possibilities of systematic error in comparison between various instruments. Implicit within the coefficients of the manufacturer's equation is a specific value for the conductivity of the standard water which may or may not be the same as that of another manufacturer. Utilization of any given equation means that the particular value selected by that manufacturer is incorporated within the final data produced.

It is strongly recommended that all new editions of operating instructions be altered so as to reflect a ratio value rather than a conductivity value. This may be achieved with trivial work by dividing through the coefficients of each factor in the equation by the value of the conductivity for standard seawater originally utilized in producing the equation.

Operators using equipment calibrated in the old fashioned way should write to the manufacturer asking for the value of conductivity used by him and carry out the division process themselves. This enables direct entry into the algorithms for the PSS 78.

Background literature on this subject may be obtained from:

Division of Marine Sciences
UNESCO
Place de Fontenoy
75700 Paris, France

In particular we refer to the following documents:

UNESCO (1981a). The practical salinity scale 1978 and the international equation of state of seawater 1980. Tenth Report of the Joint Panel on Oceanographic Tables and Standards, Sidney, B.C., September, 1980. Unesco Technical Papers in Marine Sciences, No. 36, pp. 25.

UNESCO (1981b). Background Papers and Supporting Data on the Practical Salinity Scale 1978. Unesco Technical Papers in Marine Sciences, No. 37, pp. 144.

UNESCO (1981c). Background Papers and Supporting Data on the International Equation of State of Seawater 1980. Unesco Technical Papers in Marine Sciences, No. 38, pp. 192.

UNESCO (1981d). International Oceanographic Tables, Vol. 3. Unesco Technical Papers in Marine Science, No. 39, pp. 111.

UNESCO (1983). Algorithms for Computation of Fundamental Properties of Seawater. Unesco Technical Papers in Marine Science, No. 44, pp. 53.

PART II

JOINT EDITORIAL PANEL ON THE OCEANOGRAPHIC MANUAL

Report of First Meeting,
Moscow State University,
Moscow, 30 June to 4 July 1986

REPORT OF THE MEETING OF THE JOINT EDITORIAL PANEL ON OCEANOGRAPHIC MANUAL

Moscow State University, Moscow, 30 June - 4 July 1986

1. OPENING

The meeting was opened in the Geographical Faculty of Moscow State University, at 10.30 on 30 June 1986, by the Deputy-Dean of the Faculty of Science, Prof. V. Konishev. All members of the panel were present, namely: Prof. O. Mamayev (Unesco), Dr. K. Taira (IAPSO), Dr. R. Millard (SCOR), Dr. H. Dooley (ICES) and Dr. S. Morcos (Unesco). In his opening speech, the Deputy-Dean welcomed the Panel to Moscow State University and spoke of the very valuable work that had been entrusted to the Panel. In response, Dr. S. Morcos (Unesco) formally reviewed the background to the establishment of the Panel, which had been set up under the auspices of the Joint Panel on Oceanographic Tables and Standards (JPOTS) to devise a new oceanographic manual. This manual, following the model of the publication "Processing Oceanographic Data" by E.C. LaFond, 1951 (called "LaFond Manual" hereafter) which had been used by generations of marine scientists, had become necessary following the recent endorsement by IAPSO, SCOR and ICES of the use of the Practical Salinity Scale (1978) and the International Equation of State of Seawater (1980). The full text of Dr. S. Morcos' address is given in Annex I.

1.1 Election of Chairman and Rapporteur

The Panel appointed their host, Prof. O. Mamayev, Chairman of the Editorial Panel and of this meeting. Dr. Mamayev had prepared all the documentation to provide the basis for the meeting. Dr. H. Dooley was appointed the Rapporteur of the meeting. The List of participants is given in Annex II.

1.2 Agenda

An annotated provisional agenda had been circulated to members by Dr. O. Mamayev prior to the meeting. The members agreed that this would provide a useful and effective structure for the meeting and adopted it as the agenda. It is attached as Annex III to this report.

1.3 List of Documents

Several documents prepared by Dr. O. Mamayev had been circulated to members prior to the meeting for preliminary consideration. These included a document he had prepared entitled "Preliminary Considerations on the Structure of the Future Manual for Processing of Oceanographic Data". The full List of Documents is given in Annex IV, and Dr. Mamayev's document is Annex V. Dr. K. Taira and Dr. H. Dooley also provided written contributions ("Comments/suggestions from ICES Hydrographer" and "Needs of New Manual in Japanese Oceanographic Community", respectively) and Dr. R. Millard provided the final text of Volume 4 of the International Oceanographic Tables (hereafter cited simply as "Volume 4").

2. GUIDELINES FOR THE EDITORIAL PANEL AND OBJECTIVES OF MANUAL

2.1 Guidelines

Dr. S. Morcos referred to various reports of SCOR that dealt with the reasons for the establishment of the Panel. In particular, he noted that SCOR had been invited to take the initiative in organizing the production of a manual which would provide guidance on the use of the Practical Salinity Scale (1978) and the International Equation of State of Seawater (1980), both developed by JPOTS, taking into account that users of the manual may not have computing facilities. In particular, the Panel had to examine closely any possible inter-relationship with Volume 4 which is in the process of being published by Unesco, since this manual was specifically being designed for use by individuals lacking access to computing facilities, and for educational purposes. The Panel noted that it was expected to complete its work within two years.

2.2 Objectives

The Panel accepted at the outset that the oceanographic manual they were charged with preparing, may not be of direct use to professional oceanographers who had access to the computing facilities of a modern oceanographic institute. Their needs have already been fully met by the recently published papers in the series Unesco Technical Papers in Marine Science, in particular No. 44 which describes algorithms derived from the Practical Salinity Scale (1978) and the new International Equation of State of Seawater (1980). However, it was considered that there was a real need for a basic manual describing hand processing procedures to serve other groups concerned with data collection, in particular marine biologists and fisheries scientists. It was also considered that such a manual would provide an invaluable educational tool for the training of future generations of oceanographers, for whom a fundamental grasp of the basic calculation processes was considered essential.

In defining the objectives, a primary consideration was that it should provide a simple guide to the manual calculations of oceanographic parameters, as was the case with the "LaFond Manual". The Panel had, however, some difficulty in deciding where its starting point should be, taking into account the fact that oceanographic practices had changed since the production of that manual in 1951, due to the advent of the CTD. The basis of this difficulty was the serious delay of SCOR WG 51 on Evaluation of CTD Data, in producing its report on recommended procedures on data acquisition using CTDs. However, the Panel assumed that this work would be completed in due course and considered that the independent parameters for the manual were pressure, temperature and salinity of known precision and derived from accepted procedures (as agreed by WG 51). The Panel also noted that there was a considerable quantity of data being created by conventional means, that is by water bottles and reversing thermometers, and data of this type should provide the starting point for this manual, as was the case in the "LaFond Manual", but taking into account the revision of standards and units following the adoption of the SUN Report as well as of the Practical Salinity Scale. The Panel also agreed that the basis of the demonstrations of the calculation procedures should be a selection of previously published CTD casts, reduced to selected

standard levels which would demonstrate the results of machine calculation of derived values from a high resolution data set as compared to the results of the "hand" calculations using the selected depth (low resolution) data. Adopting this approach would offer the additional benefit of providing the reader with information on the loss of precision as a result of large integration intervals that are the norm in water bottle oceanography.

3. REVIEW OF EXISTING MANUALS AND GUIDES

The Panel reviewed the contents of existing publications, including the "LaFond Manual", Zubov's oceanographic tables and other manuals prepared by data centres, including the NODC manual. It also considered several atlas-type publications and data reports including those of GEOSECS, Fuglister and that of the AJAX expedition (Annex VI). In particular, it took note of the draft of Volume 4. This volume, providing a detailed description of various oceanographic tables using the new standards, correctly employed pressure (decibar) as the independent variable dictating the need for this to be the independent variable in this manual. This represents a fundamental departure from the depth parameter used hitherto in most manuals on oceanograhic data processing (including the "LaFond Manual"). Thus the data which will be used as the basis of this manual would be derived from CTD profiles from which values of pressure, conductivity and temperature are obtained. Due account would be taken of the data derived from water bottle casts.

4. DETAILS OF THE MANUAL

In considering the details of the manual, the Panel made use of the working document prepared by Dr. O. Mamayev (Annex V), taking into account the general considerations discussed in the preceding sections. Dr. Mamayev's proposals considered a manual divided into three sections, namely: 1) Scientific Background, 2) Processing Procedures (with worked examples) and 3) Oceanographic Tables and Graphs.

4.1 Scientific Background

It was agreed that this section should consist of six sub-sections, namely:

(1) Introduction.

This would be prepared by Dr. O. Mamayev and Dr. S. Morcos, and would state the purpose of the manual, indicating the intended audience.

(2) Background and basis of computation of properties from vertical profiles of temperature-conductivity-pressure

This would describe the criteria used in the selection of the station data in the manual, stating that the data forming the basis for the processing is of selected (standard depth) CTD data, created from a data set of 2 dbar resolution. The connection of this type of data to water bottle data would be described. Drs. R. Millard and H. Dooley would prepare this sub-section.

(3) The Practical Salinity Scale (1978) and the International Equation of State of Seawater (1980).

It was appreciated that detailed descriptions were already available in the series Unesco Technical Papers in Marine Science, but the matter was sufficiently important to warrant inclusion here. The Panel considered however that a more "user-friendly" type presentation was more appropriate for the intended user of the manual. The algorithms given in Fofonoff (1985) would meet this requirement.

(4) Conversion of existing data in PSS-78, EOS-80 - dependent data.

Since there is a possibility that prospective users of the manual may have at their disposal only salinity data created from the Cox or Knudsen-Ekman salinity scales, it was necessary to provide advice on how these data may be converted to the practical salinity scale. The Panel recommended that a group be set up to provide guidance. This group should use Dr. Mamayev's recent publication on the Practical Salinity Scale (Okeanologia, Vol. XXVI, No. 3, 1986) together with previous ones, as well as the Japanese Oceanographic Data Centres' publication on the conversion of data, as the basis for its considerations. It would work by correspondence and be led by R. Perkin. Other members of the group that were suggested by the Panel were L. Lewis, N. Fofonoff, K. Taira and O. Mamayev.

(5) Thermometry

It was noted that present manuals on oceanographic data processing contained details on how to process data acquired from reversing protected and unprotected thermometers. Indeed, the "LaFond Manual" contains details of the hand calculation of thermometer corrections and includes several tables to facilitate the calculation. The Panel considered that, for the sake of completeness, the manual should contain an informative description on how to perform the calculation, and should also contain advice on how to obtain the most reliable data, including the need for careful calibration of thermometers. Dr. K. Taira agreed to prepare this section in consultation with Dr. Dooley who will contact appropriate experts from within ICES.

(6) Standard Seawater

The Panel considered that guidance was necessary in the acquisition of precise and comparable salinity values from water bottle samples. It noted in particular the concern of SCOR on the production of standard seawater in various countries. It has been suggested that the IAPSO standard water should be the basic standard which alone is calibrated against potassium chloride solution. It was therefore agreed that Dr. Culkin should prepare this section, pointing out the need to record information on the standard water batch in use, and also the availability of standard water of various salinity (e.g. K-Series, L-Series).

4.2 Processing Procedures

In discussing the contents of this part of the manual, the Panel scrutinized the draft of Volume 4, with which the manual under

consideration was to be closely aligned. It was particularly conscious of the need to avoid duplication with this volume but considered a layout that would serve to supplement it. The Panel also noted that Volume 4 covers salinity ranges up to 40, which fall short of covering the Red Sea. It is intended that the manual will extend the coverage to the ranges of salinity and temperatures encountered in the Red Sea (75% of the total volume of the Red Sea is composed of uniform water of 40.5-41 salinity and 21-22°C). In this way, it was hoped that the needs of scientific research and education would be fully catered for. As a result, the Panel considered the following to be the best formula for this section of the manual.

(1) Selected Oceanographic Stations

As decided in the preceding sections, the basis of the manual would be calculation based on at least two pairs of oceanographic (CTD) stations which consisted of data calculated using the Practical Salinity Scale (1978). It noted that this approach had been used in an appendix which had been prepared by Dr. Perkin for the draft of Volume 4. The Panel considered, however, that this appendix would create a significant overlap with the objectives of the present manual and, moreover, did not meet all the criteria set by the Panel. It therefore considered that this appendix should be withdrawn from the draft of Volume 4. However, it was agreed that the approach adopted by Dr. Perkin was entirely relevant to the objectives of the manual and his help should be sought in completing the technical details of this section.

Drs. Millard and Taira were asked to select the appropriate pairs of oceanographic stations (from the Atlantic and the Pacific), bearing in mind the guidelines set by the Panel. In particular, these stations should be full-depth profiles to at least 4,000 db pressure, with data selected at standard pressure intervals. For the purposes of informative illustration, the stations should exhibit a complex stability pattern and be in an area of significant geostrophic shear.

(2) Smoothing and interpolation of standard to non-standard pressures

This section should contain a description on how the standard depth data from the selected oceanographic stations were derived. The methods of smoothing CTD data to selected standard depths will be considered as will the various procedures to produce similar data sets from water bottle profiles. It was agreed that the help of the Chairman of WG 51, J. Crease, should be enlisted to consider the contents of this section, and that there would be close consultation with Dr. Millard (CTD) and Dr. Dooley (water bottles).

(3) Pressure to depth and depth to pressure conversion

It was noted that Volume 4 already described a procedure to convert pressure information to depth and the reader would be referred to this. However, since potential users of the manual may wish to work from data which has only depth (wire-out) information as the independent variable, a table should be provided, with explanatory information to enable depth data to be converted to pressure. Dr. Millard undertook to prepare this table.

(4) Computation of adiabatic lapse rate and potential temperatures

Using the station data described in Section (1), the methods of computation and examples would be discussed using Tables 16-20 of Volume 4. Dr. Millard will draft this section.

(5) Computation of density (anomaly of density), potential density and specific volume (specific volume anomaly) at atmospheric and elevated pressures

The Panel discussed this item in some detail, especially with regard to the adequacy of the data listed in Volume 4. In certain respects, some of these tables were not sufficient, in terms of their range and resolution, to enable accurate hand computation, but it was considered that this short-coming could be overcome by including graphs of various tables contained in Volume 4, with ranges extended. This approach would in particular help the manual to meet its educational requirement. Dr. Mamayev presented examples of graphs that could be included and agreed to give this matter more detailed consideration, based on the above discussion.

(6) Derivatives of density - Thermal expansion, saline contraction, isopycnal derivatives, etc., versus pressure

These parameters are all listed in Volume 4, and provide the capability to hand compute Brunt-Vaisala frequency. This calculation is, however, a rather cumbersome procedure and the Panel felt that the needs of the manual could best be met by the presentation of various graphs of these parameters, or, alternatively, using pressure interpolation tables that had been prepared by Dr. Mamayev. Dr. Mamayev and Dr. Millard were asked to prepare the detailed design of this section, in particular to agree on the best way to hand calculate these parameters, which may be a combination of these two possibilities.

(7) Vertical stability calculated by different methods

Informative calculations of these types would be particularly useful for the objectives of the manual. The main approach would be a demonstration of the calculation by various methods which would bring out the use of the adiabatic lapse rate and sound speed amongst other parameters. It would also demonstrate the contribution to stability from temperature and salinity separately. Dr. N. Fofonoff would be asked to contribute to this section, in consultation with Drs. R. Millard and O. Mamayev.

(8) Speed of sound in seawater

Dr. Mamayev had prepared a graph of the data tabulated in Volume 4 and the Panel agreed that this provided a useful presentation.

(9) Computation of dynamic depths (heights)

Taking into account the earlier decision by the Panel not to include the appendix in Volume 4 concerning this parameter (and related parameters), Dr. Perkin would be asked to transfer the substance of his work and to contribute to this section using the station data selected by Drs. Millard and Taira. Dr. Mamayev also agreed to keep in close touch with this work.

(10) and (11) Relative geostrophic currents, dynamic topography, available potential energy and volume transport calculations

A similar conclusion to that for section (9) was reached for this item, but it was additionally agreed that Dr. Fofonoff should be asked to contribute to the discussion (calculation) of available potential energy.

(12) Other

This section was left open pending further investigation by Dr. Mamayev on possible parameters that are accessible to hand calculation and which are used commonly in modern oceanographic literature. Possible candidates for inclusion are potential vorticity and density anomaly at deep pressure horizons, amongst others.

4.3 Discussion on overall layout of manual

The Panel considered that the general layout described above, dividing the content into two sections (Part 1 on Scientific Background and Part 2 on Processing Procedures) was the most effective way to structure the manual and would create a logical flow to the increasingly complex parameters being presented in the manual. However, it was unable to decide at present on the actual contents for a third part of the manual that may be used as an annex/appendix to describe and/or list more details from certain sections. For example, sequences of graphs and/or tables may best be included here, as was the case in the "LaFond Manual" for example. However, a decision on this need not be formally made until after Dr. Mamayev has drawn together the potential material that may be included in this section.

The Panel considered that an appropriate title for the manual which would fully describe its objectives would be: "Manual on Processing of Oceanographic Station Data". It was also agreed, based on the discussion of the preceding sections, that the proposed table of contents would be as given in Annex VII.

5. COMPUTATIONAL NEEDS FOR THE PRESENTATION OF THE MANUAL

In introducing this item, Dr. Mamayev indicated that there was some need to come to an early decision on what further processing was required, as there were financial implications for the sponsoring organizations. It was clear however that all of the bulky computations were over because we have decided to link this manual closely with Volume 4. In addition, it has been decided that the main listing of data to be used in hand calculation would be by means of graphical presentation, but some additional computations may be required in connection with this. It was not possible at this stage to decide on precisely what may be required; this must await the preliminary work to be done by Dr. Mamayev, who would, on the basis of the Proposed Table of Contents in Annex VII, promulgate amongst participants appropriate candidates for inclusion. It was also suggested that at an early stage, each member of the editorial board should go through the hand calculation procedures to ensure that the proposed manual (including tables and graphs) are complete, accurate and clear to the reader.

6. FUTURE MEETING

The Panel noted that they were expected to complete their work by the end of 1988. It was clear that this would not be possible without one further meeting of the Panel. The details of the shape and precise details of the manual had yet to be decided. Furthermore, since the Panel had delegated several aspects of the preparation of the manual to invited specialists (to be coordinated by Dr. Morcos), it was necessary to review and approve this work in a meeting. Accordingly, the Panel accepted the invitation by Dr. H. Dooley to hold the next meeting at the ICES Secretariat in Copenhagen at the end of June 1987. In order to finalize the manual and adopt its final form, the Panel considered that a third meeting will be required in the summer of 1988.

In this regard, the Chairman was reminded by Dr. Morcos of his obligation to prepare a chairman's summary for presentation to the SCOR Executive Meeting (which took place in November 1986).

Finally, the meeting adopted the following recommendation, addressed mainly to its sponsoring organizations, Unesco, SCOR, ICES and IAPSO.

RECOMMENDATION

The Unesco/ICES/SCOR/IAPSO Joint Editorial Panel on the Oceanographic Manual,

Having convened its first meeting in Moscow from 30 June to 4 July 1986,

Strongly supports the concept that the manual will be an invaluable reference for physical oceanographers and other marine scientists, as well as for educational purposes;

Agrees on the scope, objectives and provisional contents of the manual entitled "Manual on Processing of Oceanographic Station Data", and that a period of two years is required for its completion, that is, by the end of 1988;

Realizes the need for two more meetings to finalize the manual, and that some additional work on computations, graphs and design will be needed in the course of the preparation of the manual, and therefore requests Unesco, SCOR, ICES and IAPSO to provide funds for meeting expenses, contracts for consultants and computations;

Accepts the kind invitation of the ICES Secretariat to host its next meeting in Copenhagen, and requests its sponsoring organizations to support this meeting.

VISIT TO THE NORMAL SEAWATER SERVICE, ANALYTICAL LABORATORY OF P.P. SHIRSHOV INSTITUTE OF OCEANOLOGY, USSR ACADEMY OF SCIENCE, MOSCOW.

On Wednesday 2 June 1986, the members of the Panel visited the Normal (Standard) Seawater Service in Moscow, where they were met by Mrs. M. P. Nesterova and co-workers. This service was started in 1956, and produces about 10,000 ampoules of normal seawater per year (in 5 batches of about 2,000 ampoules each). The labels carry the number of the batch, the date, K15 and Cl‰. The normal seawater of the USSR is a secondary standard of the IAPSO Standard Seawater produced in Wormley, U.K. It is solely calibrated against the latter. Mrs. Nesterova affirmed that this procedure will continue and that there is no plan to standardize the USSR normal seawater against KCl solution. She confirmed that the only primary standard seawater should be that of IAPSO produced in Wormley, U.K. In reply, Dr. S. Morcos (Unesco) praised her efforts and intentions, and invited her to continue her cooperation with Dr. F. Culkin, Director of the IAPSO Standard Seawater Service. He also declared that Unesco is ready to help in advancing cooperation between the two services with a view to maintaining a high quality and reliable product.

CLOSURE OF THE MEETING

The Panel meeting was closed at 12.00 on Friday 4 July 1986, in presence of some staff members of the Geographical Faculty, who helped the Panel in its work throughout the meeting. Also present, was Dr. P. Agafonov, Secretary, Oceanographic Committee of the Soviet Union. Dr. O. Mamayev expressed his satisfaction with the meeting and its results, and his gratitude for his election as Chairman of the Panel. On behalf of the members of the Panel, as well as of the sponsoring organizations, Dr. S. Morcos expressed his appreciation of the facilities put at the disposal of the meeting, and of the efforts in making their stay in Moscow both a profitable and enjoyable one.

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ANNEX I

JOINT EDITORIAL PANEL ON OCEANOGRAPHIC MANUAL
First Meeting, Moscow, 30 June - 4 July 1986

Address by Dr. S. Morcos (Unesco)

Dear Colleagues,

It is my great pleasure to speak to you on the occasion of the first meeting of the Joint Editorial Panel on the Oceanographic Manual, taking place today in Moscow State University.

It is no exaggeration to say that the Joint Panel on Oceanographic Tables and Standards which was created in 1964, is the longest serving inter-organization body in oceanography. The Panel was formed by members nominated by Unesco, SCOR, IAPSO and ICES. Although the membership of this Panel has changed with time, it has continued its work with remarkable success and with the ability to absorb and master new ideas through the gradual progress in technology, as reflected in the precise measurement of conductivity and density of seawater. As a result, a breakthrough was accomplished and announced as the Practical Salinity Scale (1978) and the International Equation of State of Seawater (1980).

The technical details of these achievements were published as Unesco Technical Papers in Marine Science Nos. 36, 37 and 38. New International Oceanographic Tables, Volumes 3 and 4, were produced and new algorithms were published by Unesco, as Unesco Technical Papers in Marine Science Nos. 39, 40 and 44 respectively. In another parallel development, the SUN Group on Symbols, Units and Nomenclature in Physical Oceanography finalized its report which was published as Unesco Technical Papers in Marine Science No. 45 and IAPSO Publication Scientifique No. 32.

The new International Oceanographic Tables, Volume 4, entitled "Properties of Seawater derived from the Equation of State", did however encounter several delays, but is now almost ready for publication. It was during the discussions on the contents and layout of these tables that the idea of producing an "Oceanographic Manual" came up as an important point of discussion during the JPOTS Sub-Panel Meeting in Scripps Institution of Oceanography, La Jolla, U.S.A., from 5 to 8 July 1983.

During the following SCOR Executive Meeting in Paris in September 1983, the proposal to produce a manual was brought to the attention of SCOR by Unesco and JPOTS. Allow me to read the following paragraph from the SCOR Report of September 1983:

"JPOTS had recommended that SCOR undertake the preparation of a basic manual to provide guidance to the users of the Practical Salinity Scale and the International Equation of State. The President of IAPSO noted that IAPSO had passed a resolution to this effect at its General Assembly in Hamburg. After some consideration as to the appropriate agencies for completion of this task it seemed that a 'JPOTS Editorial Panel' consisting of one member representing each of the sponsors of the Panel might be the most efficient means of producing such a manual. The President of ICES and the Director of the Unesco Division of Marine Sciences concurred with this proposal which will be developed further in consultation with the Chairman of JPOTS before the next meeting of SCOR."

However, no progress was made at that time in nominating the members of the Panel. In the SCOR Meeting in Roscoff, France, in October 1984, Unesco proposed that SCOR invite each sponsoring organization to designate a member of the Panel. In addition, Unesco pointed out that "since the manual will deal with special needs of oceanographers in developing countries, small institutions and universities, attention should be given to the expertise required of the members of the Panel."

According to the Report of the SCOR Assembly of 1984, "the other co-sponsors of JPOTS have invited SCOR to take the initiative in organizing the production of an 'oceanographic manual' after the style of a volume entitled "Processing Oceanographic Data" which was prepared by Dr. E. Lafond in 1951. Such a basic manual would provide guidance to the users of the standards developed by JPOTS who may not always be highly trained marine scientists. SCOR agreed to invite each of the co-sponsors of JPOTS to nominate an individual to serve on an editorial panel which will undertake the preparation of this manual. Dr. Morcos, the representative of Unesco noted that the Division of Marine Sciences would provide funds to permit the employment of a junior scientist to assist with the collection of material for the manual."

In the following year, Unesco put forward a recommendation to the SCOR Executive that met in Seattle, in September 1985:

"Upon the advice of JPOTS and following resolutions by the IAPSO General Assembly (Hamburg, August 1983) and the SCOR Executive (Paris,

September 1983), the production of a basic manual for the users of the Practical Salinity Scale 1978 and the International Equation of State of Seawater 1980 was recommended. A JPOTS Editorial Panel consisting of one member nominated by each of the sponsoring organizations, was proposed. After active consultation between SCOR, IAPSO, ICES and Unesco, the following members were nominated: Dr. H. Dooley (ICES), Dr. O. Mamayev (Unesco), Dr. R. Millard (SCOR) and Dr. K. Taira (IAPSO). Prof. Mamayev took the initiative to begin consultation through correspondence. It is hoped that the first meeting of the Editorial Panel will be held in 1986."

In the report of the SCOR Executive in Seattle, the following statement was made:

"The production of an Oceanographic Manual by Unesco was discussed by the subpanel, and, although the usefulness of such a manual was generally agreed on, it was decided that this was not the immediate task of JPOTS, but would best be accomplished under the auspices of JPOTS. In the meantime, a panel has been appointed for this purpose by SCOR with representatives of IAPSO, ICES and Unesco and has begun its work in correspondence. The members of this panel, which will meet in late 1986, are Drs. Millard (SCOR), Taira (IAPSO), Dooley (ICES) and Mamayev (Unesco)."

As you can see, it took three years to bring us together here today. Of course, some work has been done during that period thanks to your cooperation, and the immense interest of Prof. Oleg Mamayev in seeing this manual produced. Prof. Mamayev has, indeed, been very active both in correspondence with us members of the Panel, and in the preparation of this meeting. Having said that, I should like to express Unesco's hope that this manual will be produced in the most efficient way and will be based on the experience gained in many nations and schools. We also hope that it will attract a wider audience in the oceanographic community and ensure more compatibility in oceanographic data.

Dear Colleagues, on behalf of Unesco and the sponsoring organizations, SCOR, IAPSO and ICES, let me express my thanks to the Oceanographic Committee of the Soviet Union, to the Commission of the U.S.S.R. for Unesco and the U.S.S.R. Permanent Delegation to Unesco, for their efforts in the preparation of this meeting. Our gratitude is also due to our host

institution, the Moscow State University, to its Faculty of Geography and to our oceanographic colleagues in this institution. Here, I wish to mention in particular the efforts of Dr. Peter Agafonov, Dr. Vassily Zivago and Prof. Oleg Mamayev.

Finally, I have pleasure in conveying to you the greetings of Mr. Amadou Mahtar M'Bow, the Director General of Unesco, and his best wishes for the success of this meeting.

Thank you.

ANNEX II

U N E S C O

Joint Editorial Panel on Oceanographic Manual

First Meeting, Moscow, 30 June - 4 July 1986

LIST OF PARTICIPANTS

1.	Dr. Harry D. DOOLEY, International Council for the Exploration of the Sea (ICES), Palaegade 2-4, 1261 Copenhagen K, DENMARK.	Rapporteur (ICES)
2.	Dr. Oleg MAMAYEV, Department of Oceanology, Moscow State University, Moscow 119899, U.S.S.R.	Chairman (UNESCO)
3.	Dr. Robert MILLARD, Jr. Woods Hole Oceanographic Institution, Woods Hole, MA 02543, U.S.A.	(SCOR)
4.	Dr. Selim MORCOS, Division of Marine Sciences, UNESCO, 7, place de Fontenoy, 75700 Paris, FRANCE.	(UNESCO)
5.	Dr. Keisuke TAIRA, Ocean Research Institute, University of Tokyo, Minamidai, Nakano-Ku, Tokyo 164, JAPAN.	(IAPSO)

ANNEX III

U N E S C O

Joint Editorial Panel on Oceanographic Manual

First Meeting, Moscow, 30 June - 4 July 1986

A N N O T A T E D P R O V I S I O N A L A G E N D A

1. Opening of the meeting

The meeting will be opened at 10:00, 30 June 1986, in the main building, Sector A, of the Moscow State University, Lenin Hills, on the 18th floor in the office of the Dean of the Geographical Faculty. The Dean of the Faculty will address the meeting. Then it will proceed in Room 17-17 (17th floor).
The Chairman of the Panel and the Rapporteur of the meeting shall be elected.

2. Guidelines for the Editorial Panel and Objectives of the Manual

The decisions of the governing bodies on the establishment of the Editorial Panel shall be reviewed; according to those, the Panel is to prepare "a basic manual to provide guidance to the users of the Practical Salinity Scale, 1978, and the International Equation of State of Seawater, 1980" (cf. "SCOR Proceedings", Vol. 20).
The objectives of the Manual will be discussed according to its main purpose to describe in detail procedures of processing continuous temperature and salinity (conductivity) versus pressure data collected at sea, conversion of sea observations to standard units and derivation of dependent quantities.
It is presumed that the basic (i.e. minus instrumental and other corrections) values of temperature and salinity at different depths, as usually already published in data sources, will be the starting point of the processing of oceanographic observations with the aid of the Manual. The connection with "International Oceanographic Tables", Vol. IV, will be decided.

3. Review of existing Tables and Manuals for processing oceanographic data

It is presumed that participants will bring with them and present at the meeting different sources available in their possession and currently used in oceanographic practice in different countries and

international organizations (IODE of IOC, Service hydrographique of ICES, etc.). Several sources were listed in the working paper "Preliminary considerations ...", despatched to the members of the Panel by Unesco on 3 September 1985.

4. Consideration of Preliminary Table of Contents of the Manual

The members of the Panel are asked to give advance consideration to this subject and bring their proposals to the meeting.
The draft proposal will be circulated at the meeting.
One point should be born in mind, namely whether it is needed that one particular section of the Manual be devoted to the problem of conversion of existing data to the "new" data.

5. Computational Needs for the Preparation of the Manual

Will be discussed in the course of the meeting.

6. Future Work and Meetings

Will also be discussed in the course of the meeting.

7. Closure

The meeting will be closed (presumably) at noon, 4 July 1986.

ANNEX IV

U N E S C O

Joint Editorial Panel on Oceanographic Manual

First Meeting, Moscow, 30 June - 4 July 1986

LIST OF DOCUMENTS

1. Provisional

2. Annotated Provisional Agenda

3. Table of Contents of the Manual (first draft)

4. Preliminary considerations (on the structure of the future manual for processing of oceanographic data)

5. Example of selection of a pair of stations from the AJAX Expedition (Graph)

6. AJAX Expedition, RV "Knorr" Station 66 (published data and computational examples)

7. On the comparison of the equations of state of seawater (Knudsen - Ekman's and the International, 1980) by O. I. Mamayev ("Okeanologia", 1986, Vol. XXVI, No. 3, pp. 505-513, in Russian)

ANNEX V

PRELIMINARY CONSIDERATIONS

on the structure of the future manual for processing of oceanographic data

by O.I.Mamayev

I. Besides the tables, computational graphs should be in my opinion included into the Manual *). Some good examples of such graphs, which could be used not only for the purpose of illustration, i.e. showing the character of the function, but for direct computation, might be found in the following sources:

I. Callaway E.B. Graphical determination og specific volume anomaly and current. Trans. Amer. Geophys. Union, vol. 32, no. 5, I95I.
Contain graphs for determining δ_{Sp} and δ_{Tp} (corrections to the specific volume anomaly) with the precision required for the dynamical computations. Also - samples of sheets of v,S - diagram (Δ_{ST},S - diagram). All these are quoted by LaFond on his page I5.

2. Pollak M.J. Static stability parameters in oceanography. Journ. Mar. Res., vol. I3, no. I, I954.
Two graphs of adiabatic density gradient and its pressure correction drawn on a square paper and of a very compact size (approximately only I0 x I5 cm), are presented in this article. They allow, despite their small size, to calculate adiabatic density gradients and hence vertical stability to a needed degree of precision.

3. Thorade H. Ein Nomogramm zur Bestimmung der Dichte des Seewassers. Ann. Hydrogr. maritim. Meteorol., Bd. 55, H. I, I927.
Two nomograms (folded) for determining ρ_{STp} and ν_{STp} at high pressures (up to I0 000 decibars) and temperature range of abyssal waters (-2 to +4 °C).

4. Tables of Sound Speed in Sea Water. N.O. Spec. Publication SP-58 (Supplement to H.O. Publ. 6I4). Washington, D.C., I962.
Sound speed nomogram (one folded sheet) on a square paper for determining sound speeds, C_{STp}, for the whole range of $-2 < T < 30$ °C, $0 < S < 4I$ °/oo and $0 < p < 8000$ decibars to within one meter per second.

In my view, Pollak's nomograms cited above constitute the best example

*) Graphs of large volume and extent (bulky), namely graphs for calculation of ρ or ν (such kind of graphs, "σ_t -charts") are mentioned by LaFond in a footnote (p.I6) are not considered here.

of small-scale graphs, allowing quite good accuracy, that should be recommended for inclusion into the Manual. Two other examples, graphs on a millimeter paper, are attached hereto (Figs. 1 and 2). These are the graphs on a temperature-salinity plane of partial derivatives, $10^4(\partial\rho/\partial T)$ and $-10^4(\partial v/\partial S)$ at atmospheric pressure. The second one may be without alteration used for the vertical stability calculations; the first one should probably be two times bigger in scale to serve the same purpose.

II. Besides LaFond's Manual, N.N.Zubov's "Oceanological Tables" (Gidrometeoizdat, Leningrad, 3rd Edition, 1957, 406 pp., in Russian) might be considered as one of the principal guides for preparation of the new Manual. These tables include 227 tables and consist of eleven sections and an Appendix, including three worked examples. "Oceanographical Tables" (Gidrometeoizdat, Leningrad, 4th Edition, 1975, 477 pp., in Russian) succeed Zubov's tables and contain 234 tables.

III. Besides the manuals and guides of LaFond's or Zubov's type, extensive tables and graphs for calculating Sigma - T or specific volume (at atmospheric pressure) were published several times. Of these the most important issues should be mentioned:

1. Tables for Sea Water Density. H.O. Publ. No. 615, Washington, D.C., 1952, 265 pp.

   Multicoloured sheets for calculating Sigma-T practically to a very good precision of 10^{-3}.

2. Kalle K. und Thorade H. Tabellen und Tafeln für die Dichte des Seewassers (σ_T). Aus dem Archiv der Deutschen Seewarte und des Marineobservatorium, 60. Band, Nr. 2, 1940.

   Multicoloured sheets for determining Sigma - T to within 10^{-2}.

3. Zubov N.N. and Sirotov K.M. Album of Oceanological Graphs. Gidrometeoizdat, Moscow, 1942, 55 pp., in Russian.

   Album of 23 x 32 cm size containing, among others, 29 sheets of T,S - diagrams for determining specific volume at atmospheric pressure for the range of $2 < S < 40^{\circ}/_{oo}$, $-2 < T < 33^{\circ}C$. Graphs are built on a millimatar paper in a scale: 1° = 1 cm, $1\ ^{\circ}/_{oo}$ = 10 cm, which allows to determine specific volume to within 10^{-5}.

IV. The Manual should contain worked examples based on two (or more) very good oceanographic stations, occupied down to the bottom (e.g.,stations

from GEOSECS Expeditions) presenting detailed computations of vertical distribution of parameters and functions based on application of PSS-78 and EOS-80 to the values measured at sea, namely:

- pressure (from depth) or vica versa;
- density (sigma-T, density in situ, potential density), specific volume anomaly etc.;
- Dynamic height anomaly (differences of these anomalies and Jackhelln's transport functions for two nearby stations also);
- adiabatic lapse rate and potential temperature;
- Brunt-Väisälä frequency (vertical stability) calculated by different methods;
- available potential energy, steric deviations;
- other internal parameters (dependant on stratification) etc.

This list, of cource, is provisional. Calculations based on other than vertical stations oceanographical data may also be taken into consideration.

V. The above considerations can be detailed greately if they prove relevant.

6 August 1985

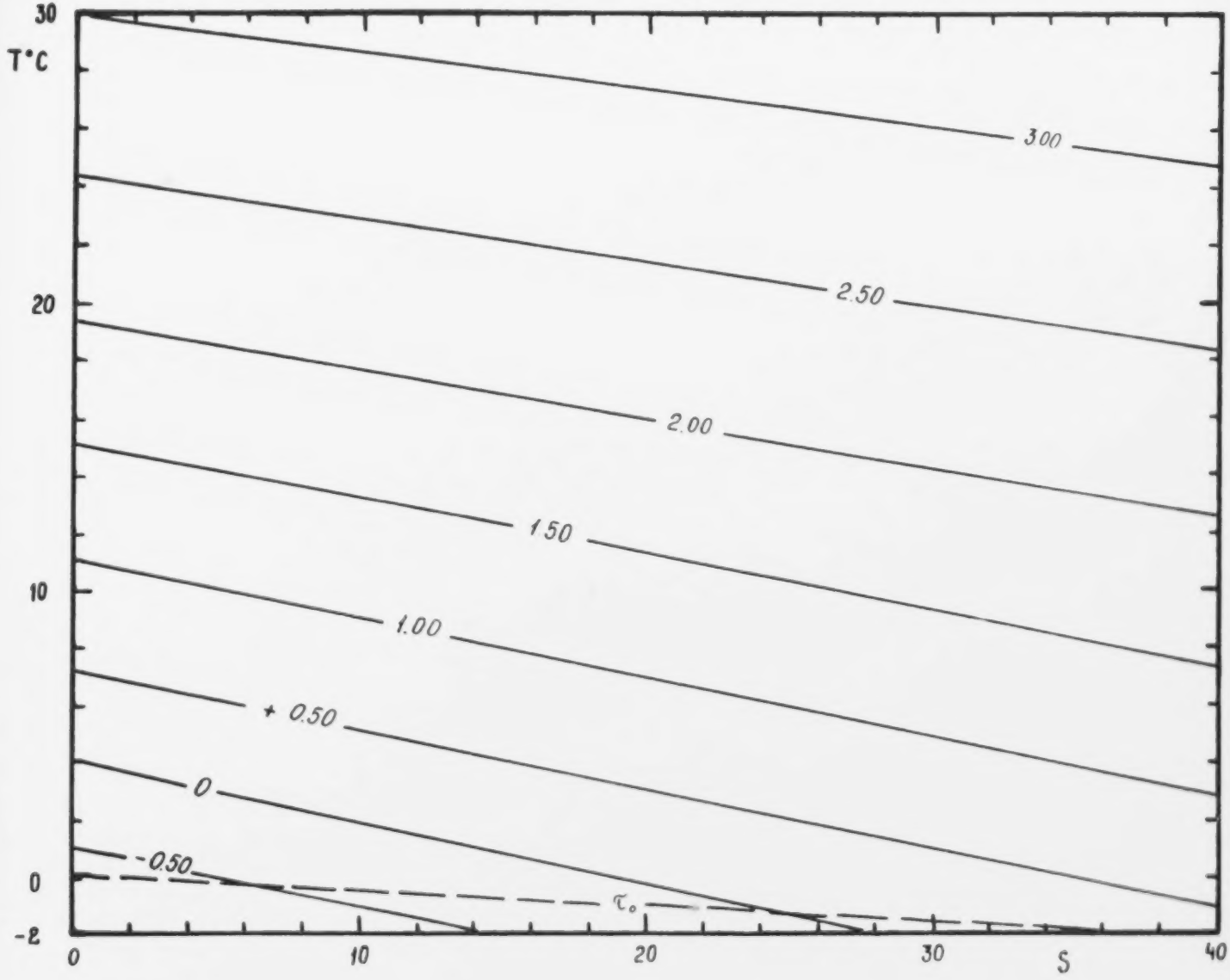

Fig. 1: Coefficient of thermal expansion of seawater, $10^4\alpha = -10^4(1/\rho)(\partial\rho/\partial T)$ at atmospheric pressure. Dashed line shows the freezing temperature, τ_o.

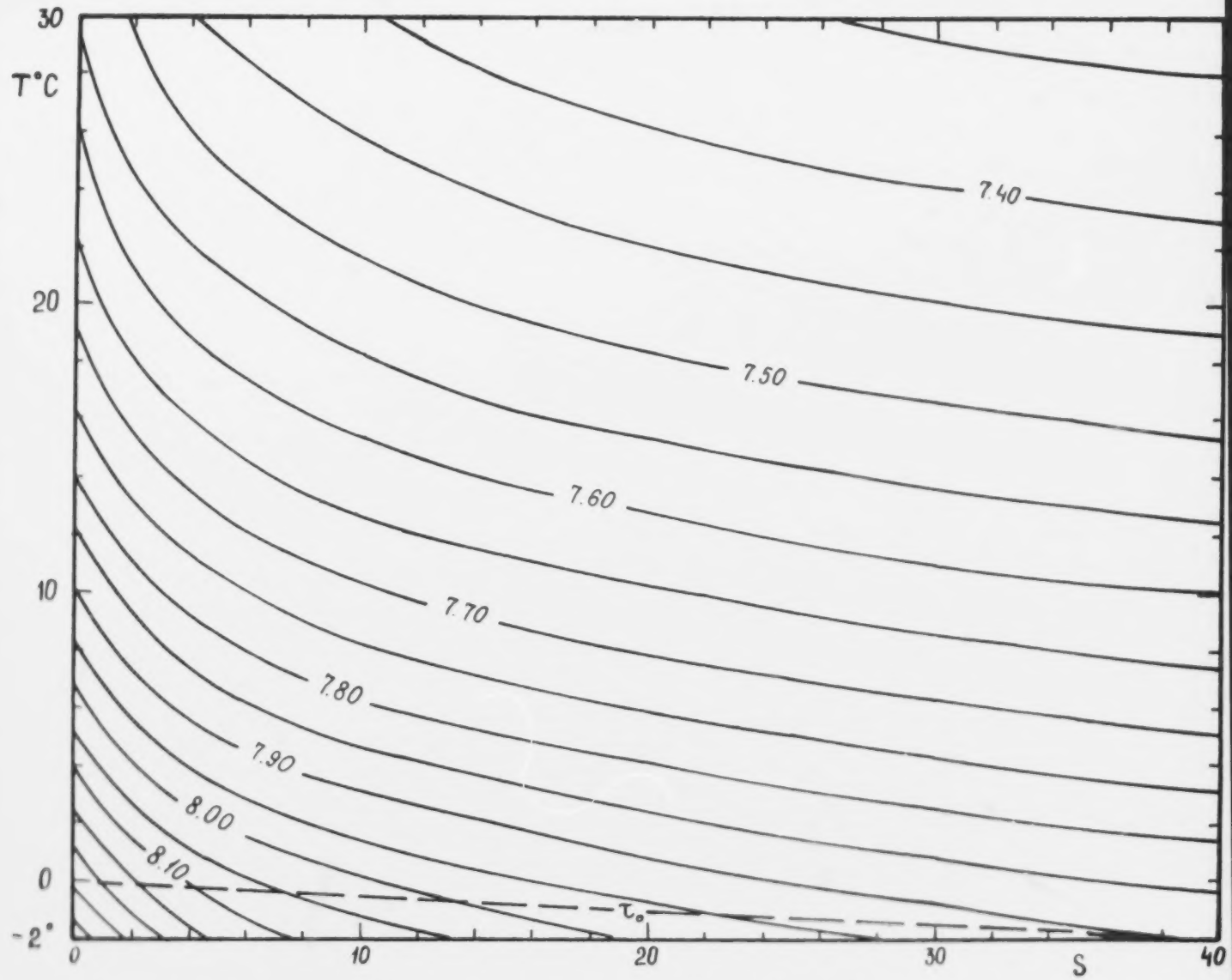

Fig. 2: Coefficient of saline "contraction" of seawater, $10^4\beta = 10^4(1/\rho)(\partial\rho/\partial S)$ at atmospheric pressure. Dashed line shows the freezing temperature, τ_o.

TABLE 1: AJAX EXPEDITION, RV "KNORR", STATION 66, 17 JANUARY 1984

Z(m)	T(°C)	θ(°C)	S	σ_θ	δ	D	p (dbar)
0	9.673	9.673	34.I44	26.339	I67.5	0.000	0
I0	9.663	9.662	34.I43	26.340	I67.6	0.0I7	I0
20	9.664	9.662	34.I43	26.340	I67.9	0.034	20
30	9.657	9.654	34.I44	26.342	I67.9	0.050	30
40	9.489	9.485	34.I54	26.378	I64.7	0.067	40
50	9.349	9.343	34.I73	26.4I6	I6I.3	0.083	50
75	8.246	8.238	34.29I	26.68I	I36.4	0.I20	76
I00	7.387	7.377	34.306	26.9I8	I23.6	0.I53	I0I
I25	6.997	6.985	34.258	26.836	I22.3	0.I84	I26
I50	6.807	6.792	34.263	26.867	II9.8	0.2I4	I5I
I75	6.842	6.826	34.300	26.89I	II7.9	0.244	I76
200	6.735	6.7I7	34.347	26.943	II3.4	0.273	202
225	6.5I7	6.497	34.34I	26.968	III.3	0.30I	227
250	6.I24	6.I02	34.308	26.993	I09.I	0.328	252
275	5.756	5.733	34.290	27.025	I06.2	0.355	277
300	5.5I9	5.494	34.28I	27.047	I04.3	0.38I	303
350	4.775	4.748	34.2I9	27.085	I00.7	0.433	353
400	4.372	4.342	34.202	27.II5	97.9	0.482	404
450	4.I20	4.087	34.I95	27.I37	96.2	0.53I	454
500	3.952	3.9I6	34.I95	27.I54	94.7	0.579	505
550	3.725	3.686	34.I98	27.I80	92.5	0.625	555
600	3.569	3.527	34.20I	27.I98	9I.0	0.67I	606
700	3.2I2	3.I65	34.2I9	27.247	86.6	0.760	707
800	2.930	2.927	34.250	27.293	82.5	0.845	808
900	2.84I	2.78I	34.287	27.335	78.9	0.925	909
I000	2.746	2.680	34.340	27.387	74.6	I.002	I0I0
II00	2.675	2.602	34.399	27.440	70.0	I.074	III2
I200	2.66I	2.580	34.453	27.486	66.4	I.I43	I2I3
I300	2.670	2.58I	34.503	27.525	63.4	I.208	I3I4
I400	2.643	2.546	34.556	27.57I	59.7	I.269	I4I6
I500	2.527	2.423	34.586	27.605	56.7	I.327	I5I7
I600	2.488	2.376	34.6I8	27.635	54.4	I.383	I6I9
I800	2.537	2.408	34.697	27.696	50.3	I.488	I822
2000	2.493	2.346	34.747	27.74I	47.2	I.585	2025
2200	2.447	2.283	34.777	27.770	45.5	I.678	2229
2400	2.273	2.093	34.786	27.793	43.5	I.767	2433
2600	2.097	I.902	34.783	27.805	42.3	I.853	2637
2800	I.903	I.692	34.773	27.8I4	4I.2	I.936	284I

TABLE 1: AJAX EXPEDITION, RV "KNORR", STATION 66, 17 JANUARY 1984 (cont'd)

z(m)	T(°C)	θ(°C)	S	σ_θ	δ	D	p(dbar)
2800	I.903	I.692	34.773	27.8I4	4I.2	I.936	284I
3000	I.775	I.547	34.772	27.824	40.2	2.0I8	3045
3200	I.558	I.3I5	34.758	27.829	38.7	2.096	3249
3400	I.434	I.I74	34.750	27.833	38.I	2.I73	3454
3600	I.256	0.979	34.736	27.834	36.9	2.248	3659
3800	I.I34	0.839	34.732	27.84I	35.9	2.32I	3864
4000	I.02I	0.708	34.722	27.84I	35.2	2.392	4069
4200	0.993	0.659	34.724	27.845	34.9	2.462	4275
4400	0.938	0.582	34.7I5	27.843	35.0	2.532	4480
4600	0.888	0.5II	34.705	27.839	35.2	2.602	4686
4704	0.880	0.49I	34.703	27.839	35.3	2.639	4793

COMPUTATION OF VERTICAL STABILITY

AJAX EXPEDITION, RV "KNORR", STATION 66

Explanations to Table 2

The vertical distribution of stability is calculated by two methods: by Hesselberg and Sverdrup's formula

$$10^8 E = 10^4 \alpha \cdot 10^4 \left[(dT/dz) - \Gamma\right] + 10^4 \beta \cdot 10^4 (dS/dz)$$

(columns 5 - 22 of the Table) and through potential density ρ_θ, tabulated in AJAX Expedition Station Data, i.e. by formula

$$10^8 E = 10^8 (1/\rho_\theta)(d\rho_\theta/dz)$$

(column 23 of the Table).

Column 1 - Depth, meters

2 - Temperature, °C

3 - Salinity (practical salinity units)

4 - Density anomaly

5 - Temperature gradient, $10^4 (dT/dz)$

6 - Adiabatic temperature gradient, $10^4 \Gamma_{STO}$, at atmospheric pressure

7 - Temperature-pressure correction, $10^4 \Delta\Gamma_{Tp}$

8 - Salinity-pressure correction, $10^4 \Delta\Gamma_{Sp}$

9 - Adiabatic temperature gradient, $10^4 \Gamma_{STp}$, in situ (the sum of values in 6, 7 and 8)

10 - The difference, $10^4 \left[(dT/dz) - \Gamma\right]$

11 - Coefficient of thermal expansion, $10^4 \alpha_{STO}$, at atmospheric pressure

12 - Temperature-pressure correction, $10^4 \Delta\alpha_{Tp}$

13 - Salinity-pressure correction, $10^4 \Delta\alpha_{Sp}$

14 - Coefficient of thermal expansion, $10^4 \alpha_{STp}$, in situ (the sum of values in 11, 12 and 13)

15 - Temperature stability (values in 10 multiplied by values in 14)

16 - Salinity gradient, $10^4 (dS/dz)$

17 - Coefficient of saline contraction, $10^4 \beta_{STO}$, at atmospheric pressure

18 - Salinity-pressure correction, $10^4 \Delta\beta_{Sp}$

19 - Temperature-pression correction, $10^4 \Delta\beta_{Tp}$

20 - Coefficient of saline contraction, $10^4 \beta_{STp}$, in situ (the sum of values in 17, 18 and 19)

21 - Salinity stability (values in 16 multiplied by values in 20)

Computation of vertical stability (cont'd)

Column 22 - Total stability (the sum in 15 and 21) by Hesselberg and Sverdrup's formula

23 - Stability calculated as the relative gradient of potential density

NOTE: The computations are based on the BOS-80.

TABLE 2: COMPUTATION OF VERTICAL STABILITY - AJAX EXPEDITION, RV "KNORR", STATION 66

I	2	3	4	5	6	7	8	9	I0	II	I2	I3	I4	I5	I6	I7	I8	I9	20	2I	22	23
0	9.67	34.I44	26.340	-I0	I.II	0.00	0	I.II	-II	-I.6I8	-0.00I	0	-I.6I9	I8	-I.0	7.6I4	0.000	0	7.6I4	-8	I0	I0
I0	9.66	34.I43	26.340	0	I.II	0.00	0	I.II	-I	-I.6I8	-0.003	0	-I.62I	2	0	7.6I4	-0.00I	0	7.6I3	0	2	0
20	9.66	34.I43	26.340	0	I.II	0.00	0	I.II	-I	-I.6I8	-0.005	0	-I.623	2	I.0	7.6I4	-0.002	0	7.6I2	8	I0	I9
30	9.66	34.I44	26.34I	-I70	I.II	0.00	0	I.II	-I7I	-I.608	-0.007	0	-I.6I5	276	I0.0	7.6I6	-0.003	0	7.6I3	76	352	35I
40	9.49	34.I54	26.376	-I40	I.09	0.0I	0	I.I0	-I4I	-I.592	-0.008	0	-I.600	226	I9.0	7.6I8	-0.004	0	7.6I4	I45	37I	370
50	9.35	34.I73	26.4I4	-440	I.05	0.0I	0	I.06	-44I	-I.530	-0.0II	0	-I.54I	680	47.2	7.632	-0.006	0	7.626	360	I040	I032
75	8.25	34.29I	26.679	-344	0.96	0.0I	0	0.97	-345	-I.428	-0.0I7	0	-I.445	499	6.0	7.652	-0.009	0	7.643	46	545	538
I00	7.39	34.306	26.8I8	-I56	0.93	0.0I	0	0.94	-I57	-I.362	-0.024	0	-I.386	2I8	-I9.2	7.665	-0.0II	0	7.654	-I47	7I	66
I25	7.00	34.258	26.834	-76	0.9I	0.02	0	0.93	-77	-I.329	-0.028	0	-I.357	I04	2.0	7.673	-0.0I4	0	7.659	I5	II9	I2I
I50	6.8I	34.263	26.864	+I2	0.90	0.02	0	0.92	+II	-I.32I	-0.033	0	-I.354	-I5	I4.8	7.675	-0.0I6	0	7.659	II3	98	93
I75	6.84	34.300	26.889	-40	0.90	0.03	0	0.93	-4I	-I.3I8	-0.039	0	-I.357	56	I8.8	7.675	-0.0I9	0	7.656	I43	I99	203
200	6.74	34.347	26.940	-88	0.88	0.03	0	0.9I	-89	-I.30I	-0.045	0	-I.346	I20	-2.4	7.679	-0.02I	0	7.658	-I8	I02	97
225	6.52	34.34I	26.965	-I60	0.86	0.03	0	0.89	-I6I	-I.266	-0.05I	0	-I.3I7	2I2	-I3.2	7.687	-0.024	0	7.663	-I0I	III	97
250	6.I2	34.308	26.990	-I44	0.83	0.04	0	0.87	-I45	-I.224	-0.056	0	-I.280	I86	-7.2	7.696	-0.027	0	7.669	-55	I3I	I25
275	5.76	34.290	27.02I	-96	0.80	0.04	0	0.84	-97	-I.I9I	-0.06I	0	-I.252	I2I	-3.6	7.703	-0.030	0	7.673	-28	93	86
300	5.52	34.28I	27.044	-I48	0.78	0.05	0	0.83	-I49	-I.I34	-0.07I	0	-I.205	I80	-I2.4	7.7I5	-0.034	0	7.68I	-95	85	74
350	4.78	34.2I9	27.08I	-78	0.72	0.06	0	0.78	-79	-I.066	-0.085	-0.00I	-I.I52	9I	-3.4	7.729	-0.040	0	7.689	-26	65	58
400	4.37	34.202	27.II3	-50	0.69	0.07	0	0.76	-5I	-I.023	-0.I00	-0.00I	-I.I24	57	-I.4	7.738	-0.046	0	7.692	-II	46	43
450	4.I2	34.I95	27.I33	-34	0.68	0.08	0	0.76	-35	-I.004	-0.II4	-0.00I	-I.II9	39	0	7.743	-0.05I	0	7.692	0	39	33
500	3.95	34.I95	27.I5I	-46	0.66	0.08	0	0.74	-47	-0.979	-0.I28	-0.00I	-I.I08	52	0.6	7.748	-0.056	0	7.692	5	57	5I
550	3.72	34.I98	27.I77	-30	0.64	0.09	0	0.73	-3I	-0.958	-0.I39	-0.00I	-I.098	34	0.6	7.753	-0.062	0	7.69I	5	39	35
600	3.57	34.20I	27.I94	-36	0.62	0.II	0	0.73	-37	-0.927	-0.I59	-0.00I	-I.087	40	I.8	7.760	-0.07I	0	7.689	I4	54	48
700	3.2I	34.2I9	27.243	-23	0.60	0.I2	0	0.72	-24	-0.893	-0.I83	-0.00I	-I.077	26	3.I	7.768	-0.083	0	7.685	24	50	45
800	2.98	34.250	27.288	-I4	0.58	0.I4	0	0.72	-I5	-0.872	-0.207	-0.00I	-0.080	I6	3.7	7.773	-0.095	0	7.678	28	44	4I
900	2.84	34.287	27.330	-9	0.58	0.I6	0	0.74	-I0	-0.859	-0.232	-0.00I	-I.092	II	5.3	7.776	-0.I07	0	7.669	4I	52	5I
I000	2.75	34.340	27.38I	-7	0.57	0.I8	0	0.75	-8	-0.850	-0.256	-0.00I	-I.I07	9	5.9	7.778	-0.II8	0	7.660	45	54	52
II00	2.68	34.399	27.434	-2	0.56	0.I9	0	0.75	-3	-0.846	-0.280	-0.00I	-I.I27	3	5.4	7.779	-0.I28	0	7.65I	4I	44	45
I200	2.66	34.453	27.479	+I	0.56	0.2I	0	0.77	0	-0.847	-0.305	-0.00I	-I.I53	0	5.0	7.778	-0.I38	0	7.640	38	38	38
I300	2.67	34.503	27.5I8	-3	0.57	0.22	0	0.79	-4	-0.848	-0.330	-0.00I	-I.I79	5	5.3	7.778	-0.I49	0	7.629	40	45	45
I400	2.64	34.556	27.562	-II	0.56	0.24	0	0.80	-I2	-0.84I	-0.354	-0.00I	-I.I96	I7	3.0	7.78I	-0.I60	0	7.62I	23	40	33
I500	2.53	34.586	27.596	-4	0.56	0.25	0	0.8I	-5	-0.832	-0.379	-0.00I	-I.2I2	6.0	3.2	7.783	-0.I7I	0	7.6I2	24.4	30.4	29
I600	2.49	34.6I8	27.625	+2.5	0.56	0.28	0	0.84	+I.7	-0.833	-0.4I6	-0.00I	-I.25I	-2.I	4.0	7.782	-0.I87	0	7.595	30.4	28.3	30
I800	2.54	34.697	27.685	-2.5	0.56	0.3I	0	0.87	-3.4	-0.835	-0.455	-0.00I	-I.29I	4.4	2.5	7.783	-0.209	0	7.574	I8.9	23.3	22
2000	2.49	34.747	27.729	-2.0	0.56	0.34	0	0.90	-2.9	-0.832	-0.503	-0.00I	-I.336	3.9	I.5	7.784	-0.23I	0	7.553	II.3	I5.2	I4
2200	2.45	34.777	27.756	-9.0	0.55	0.38	0	0.93	-9.9	-0.8I6	-0.556	-0.00I	-I.373	I3.6	0.4	7.786	-0.253	0	7.533	3.0	I6.6	II
2400	2.27	34.786	27.779	-8.5	0.53	0.4I	0	0.94	-9.4	-0.798	-0.6I2	-0.00I	-I.4II	I3.3	0.2	7.79I	-0.275	0	7.5I6	-I.5	7.9	5.8
2600	2.I0	34.783	27.790	-I0.0	0.52	0.44	0	0.96	-II.0	-0.774	-0.665	-0.00I	-I.440	I5.8	0.5	7.796	-0.296	0	7.500	-3.8	I2.0	4.4

TABLE 2: COMPUTATION OF VERTICAL STABILITY - AJAX EXPEDITION, RV "KNORR", STATION 66 (Cont'd)

I	2	3	4	5	6	7	8	9	I0	II	I2	I3	I4	I5	I6	I7	I8	I9	20	2I	22	23
2800	I.90	34.773	27.798	-6.0	0.50	0.47	0	0.97	-7.0	-0.753	-0.7I5	-0.00I	-I.469	I0.3	-0.0	7.800	-0.3I8	0	7.482	-0.4	9.9	4.9
3000	I.78	34.772	27.807	-II.0	0.49	0.5I	0	I.00	-I2.0	-0.732	-0.763	-0.00I	-I.496	I8.0	-0.7	7.805	-0.340	0	7.465	-5.2	I2.8	2.4
3200	I.56	34.758	27.8I2	-6.5	0.48	0.54	0	I.02	-7.5	-0.7II	-0.8I4	-0.002	-I.527	II.5	-0.4	7.8I0	-0.363	0	7.447	-3.0	8.5	I.9
3400	I.43	34.750	27.8I4	-8.5	0.46	0.58	0	I.04	-9.5	-0.692	-0.864	-0.002	-I.558	I4.8	-0.7	7.8I4	-0.386	0	7.428	-5.2	9.6	0.5
3600	I.26	34.736	27.8I6	-6.5	0.45	0.6I	0	I.06	-7.6	-0.672	-0.9I2	-0.002	-I.586	I2.I	-0.2	7.8I9	-0.408	0	7.4II	-I.5	I0.6	3.4
3800	I.I3	34.732	27.82I	-5.5	0.44	0.64	0	I.08	-6.6	-0.656	-0.958	-0.002	-I.6I6	I0.7	-0.5	7.823	-0.428	0	7.395	-3.7	7.0	0.0
4000	I.02	34.722	27.82I	-I.5	0.43	0.67	0	I.I0	-2.6	-0.646	-I.004	-0.002	-I.652	4.3	0.I	7.825	-0.449	-0.00I	7.375	+0.7	5.0	I.9
4200	0.99	34.724	27.825	-2.5	0.43	0.70	0	I.I3	-3.6	-0.64I	-I.050	-0.002	-I.693	6.I	-0.4	7.826	-0.469	-0.00I	7.356	-2.9	3.2	-I.0
4400	0.94	34.7I5	27.82I	-2.5	0.42	0.73	0	I.I5	-3.6	-0.635	-I.096	-0.003	-I.734	6.2	-0.5	7.827	-0.489	-0.00I	7.337	-3.7	2.5	-I.9
4600	0.89	34.705	27.8I6	-I.0	0.42	0.75	0	I.I7	-2.2	-0.63I	-I.II7	-0.003	-I.75I	3.9	-0.2	7.828	-0.500	-0.00I	7.327	-I.5	2.4	0.0
4704	0.88	34.703	27.8I5																			

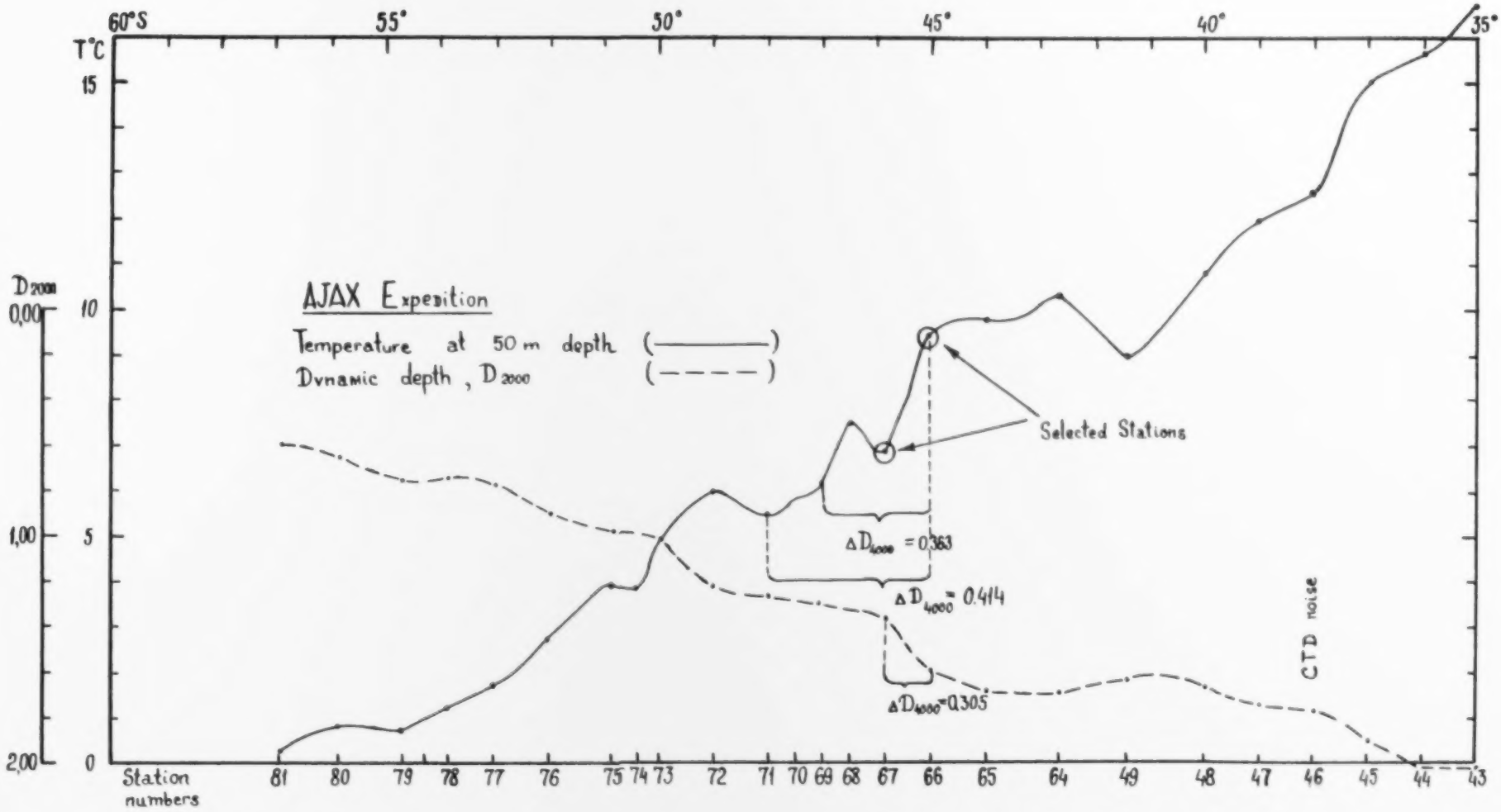

Fig. 3: Temperature at 50m depth (solid line) and dynamic height, 2000 - 0 decibars (dashed line) along the AJAX Expedition section in the South Atlantic Ocean. The selected processing stations, Nos. 66 and 67, are situated in the area of strong horizontal gradients of the above values.

65

66

PROPOSED TABLE OF CONTENTS OF THE

MANUAL ON PROCESSING OF OCEANOGRAPHIC STATION DATA

PART I. Scientific Background

1. Introduction
2. Background and basis of computation of properties from vertical profiles of temperature-conductivity-pressure
3. Practical Salinity Scale, 1978 and the International Equation of State of Seawater, 1980
4. Conversion of existing data into PSS-78, EOS-80 - dependent data
5. Thermometry
6. Standard seawater

PART II. Processing Procedures (with worked examples)

1. Selected oceanographic stations
2. Smoothing and interpolation of standard to non-standard pressures
3. Pressure to depth and depth to pressure conversion
4. Computation of adiabatic lapse rate and potential temperatures
5. Computation of density (anomaly of density), potential density and specific volume (specific volume anomaly) at atmospheric and elevated pressures
6. Derivatives of density - Thermal expansion, saline contraction, isopycnal derivatives, etc., versus pressure
7. Vertical stability calculated by different methods
8. Speed of sound in seawater
9. Computation of dynamic depths (heights)
10. Relative geostrophic currents - Dynamical topography
11. Available potential energy and volume transport calculations
12. Other (Potential vorticity)

PART III. Oceanographic Tables and Graphs

References

UNESCO TECHNICAL PAPERS IN MARINE SCIENCE

Titles of numbers which are out of stock

No.		Year	SCOR WG
1	Incorporated with Nos. 4, 8 and 14 in No. 27	1965	WG 10
2	Report of the first meeting of the joint group of experts on photosynthetic radiant energy held at Moscow, 5-9 October 1964. Sponsored by Unesco, SCOR and IAPO	1965	WG 15
3	Report on the intercalibration measurements in Copenhagen, 9-13 June 1965. Organized by ICES	1966	—
4	Incorporated with Nos. 1,8 and 14 in No. 27	1966	WG 10
5	Report of the second meeting of the joint group of experts on photosynthetic radiant energy held at Kauizawa, 15-19 August 1966. Sponsored by Unesco, SCOR, IAPO	1966	WG 15
6	Report of a meeting of the joint group of experts on radiocarbon estimation of primary production held at Copenhagen, 24-26 October 1966. Sponsored by Unesco, SCOR, ICES	1967	WG 20
7	Report of the second meeting of the Committee for the Check-List of the Fishes of the North Eastern Atlantic and on the Mediterranean, London, 20-22 April 1967	1968	—
8	Incorporated with Nos. 1, 4 and 14 in No. 27	1968	WG 10
9	Report on intercalibration measurements, Leningrad, 24-28 May 1966 and Copenhagen, September 1966; organized by ICES	1969	—
10	Guide to the Indian Ocean Biological Centre (IOBC), Cochin (India), by the Unesco Curator 1967-1969 (Dr. J. Tranter)	1969	—
11	An intercomparison of some current meters, report on an experiment at WHOI Mooring Site "D", 16-24 July 1967 by the Working Group on Continuous Current Velocity Measurements. Sponsored by SCOR, LIAPSO and Unesco	1969	WG 21
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13	Technical report of sea trials conducted by the working group on photosynthetic radiant energy, Gulf of California, May 1968; sponsored by SCOR, IAPSO, Unesco	1969	WG 15
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20	Ichthyoplankton. Report of the CICAR Ichthyoplankton Workshop-*Also published in Spanish*	1975	—
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24	Seventh report of the joint panel on oceanographic tables and standards, Grenoble, 2-5 September 1975; sponsored by Unesco, ICES, SCOR, IAPSO	1976	WG 10
27	Collected reports of the joint panel on oceanographic tables and standards, 1964-1969	1976	WG 10
28	Eighth report of the joint panel on oceanographic tables and standards, Woods Hole, U.S.A., sponsored by Unesco, ICES, SCOR, IAPSO	1978	WG 10
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